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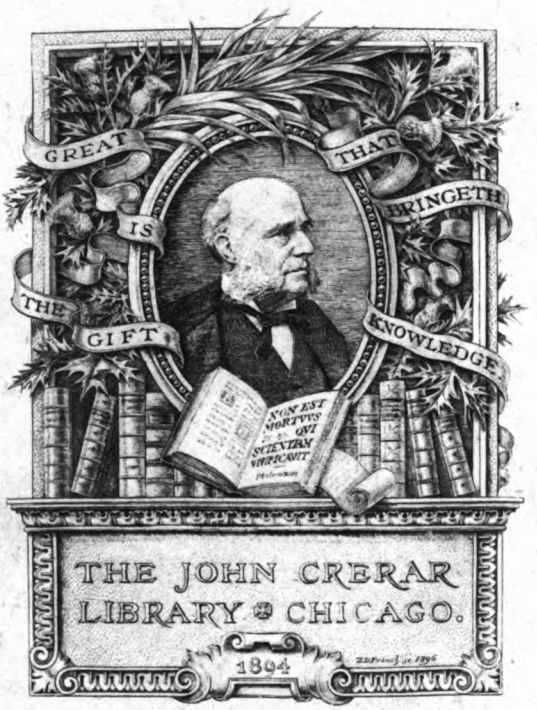

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Popular Radio

15¢

JULY
1922

THERE ARE NO ETHER WAVES

A new and revolutionary conception of radiant energy that demolishes present-day theories of electromagnetic wave motion

By Charles P. Steinmetz

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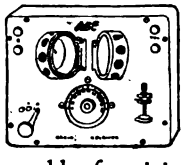
ABC Standardized Radio UNITS Sectional Receiving

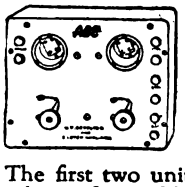
THE three ABC units here shown form the ideal combination for a receiving set. They may be purchased one at a time if desired, enabling you to add to your station at any time without discarding any previous equipment.

We have a very complete, interesting and educational catalog which you should have. Ask your dealer or write us.



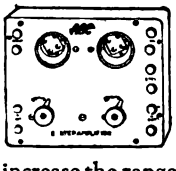
No. 5010 Crystal Detector

This first unit is capable of receiving wireless telephone up to 25 miles. The only accessories needed are the "completion package" and 2,000 Ohm head set, making the total price $40.00



No. 5013 Combination Detector and Amplifier

The first two units make a vacuum tube outfit capable of receiving wireless telephone up to 150 miles, Price $37.50: and for both units complete, except storage battery . . $94.70



No. 5014 Two-Step Amplifier

The third unit will increase the range and signal strength of the two previous units very considerably. Price for this unit alone, $45.00: or for the three units complete, except storage battery, $155.55

Jewett Manufacturing Corp.

342 Madison Ave., Dept. D7, New York

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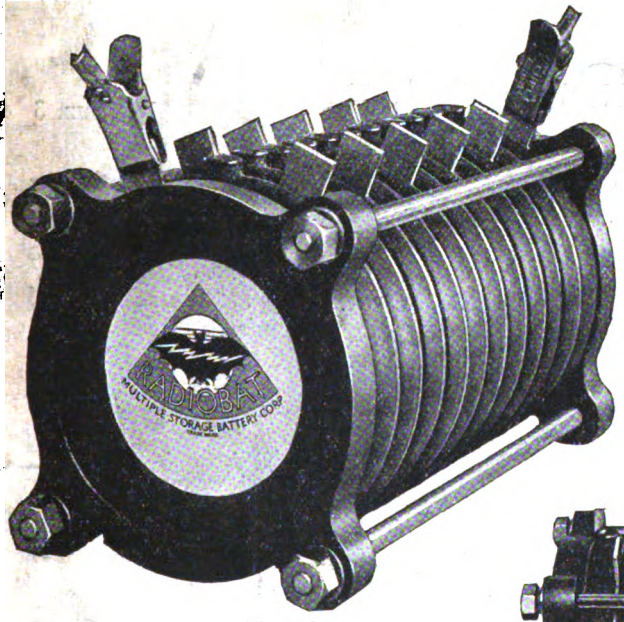
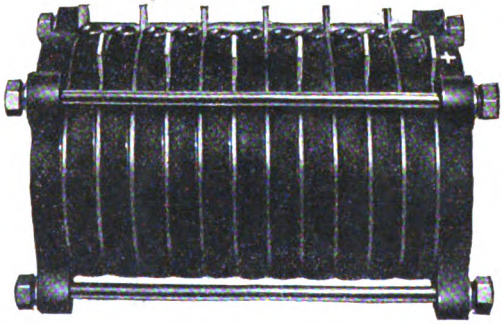
The Multiple Storage Battery Corporation Announces

RADIOBAT "B"



The Most Remarkable "B" Type Radio Battery

Revolutionary in Design and Construction



Radiobat "B" is practically everlasting. It has no glass to break, no wooden case to rot, no separators of any kind. Radiobat "B" is leak-proof, it is free from acid fumes.

Any voltage desired can be obtained simply and easily. Radiobat "B" will give a clearer tone to your Radio.

Also for laboratories and Experimenters interested in high voltage with low amperage.

As Radiobat "B" has just been placed on the market, it is possible that your regular dealer will not be able to supply it. If this is the case, write us today enclosing $12.00, the price of this extraordinary battery.

MULTIPLE
STORAGE BATTERY CORP.

350 MADISON AVENUE, NEW YORK

Dealers write at once for our proposition

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POPULAR RADIO

VOLUME I

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VOLUME I JULY, 1922 NUMBER 3

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KENDALL BANNING, *Editor* LAURENCE M. COCKADAY, R.E., *Technical Editor*

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A PAGE WITH THE EDITOR

WHEN the Circulation Manager admits that the remarkable newsstand sales of a magazine is overdue partly to the excellence of the product and not solely to his remarkable abilities as a circulation manager, then the Editor may safely conclude that he is dealing with an Honest Man. Read what our Circulation Manager Reports:

"Dealers agree that POPULAR RADIO will lead the field. Its general make up, covers and contents are perfect. The editors certainly are doing a wonderful job, and the attached figures are the very best evidence of it."

The "attached figures" of copies actually sold show a sale of 93 percent in the Boston district!

The Editors bow, and extend to the Circulation Manager the ancient Chinese blessing, "We hope you will live a million years and have a thousand children."

* * *

HERE is a letter that warms the cockles of the heart; it comes from Tottenville, New York:

"At a monthly meeting of the Tottenville Radio Club last night, it was decided to adopt POPULAR RADIO as our official club magazine. The members were highly enthused over it and declared it to be the best all-around magazine now on sale."

ROBERT A. FULLER.

* * *

AND here are three typical letters from widely scattered points that indicate that POPULAR RADIO is really accomplishing one of its main objects—to tell the layman about radio in terms that he can clearly understand:

"Your descriptions of the construction and operation of a radio set are the best that I have seen. They are written in plain English and illustrated in a way that a novice can understand."

R. H. INNES, *Dallas, Texas.*

"It is written in plain and very understandable language. All radio fans should take it to understand how to install and work their sets in the most efficient way."

EDMUND R. COLWELL, *Montclair, N. J.*

"I believe that POPULAR RADIO is the best and most helpful book for the money on the market."

A. E. HARP, *San Francisco, Calif.*

* * *

AMONG the leading radio experts who have undertaken to contribute to POPULAR RADIO since our last number went to press are some of the foremost scientists in the world—including Major-General George O. Squier, the father of "wired wireless," Professor J. H. Morecroft of Columbia University, John V. L. Hogan, Dr. Clayton H. Sharp and Minton Cronkhite.

INCIDENTALLY,—as further evidence of the quality of the magazine—just glance over the list of famous artist contributors! The striking cover design on this number was drawn by C. B. Falls, one of the most distinguished poster artists in the world. Next month's cover has been painted by Harry Townsend, one of the eight Official Artists of the A. E. F. Other artist-contributors are Adolph Treidler, Joseph Cummings Chase, Franklin Booth, Henry Reuterdahl (the Official Artist of the U. S. Navy), Gerald Leake, Frederic Stanley, J. Clinton Shepherd, Orson Lowell——and Don Herold and Clare Briggs, the famous cartoonists. National celebrities, every one of them!

* * *

THIS letter from Belington, West Virginia, sounds a timely warning:

"I am enclosing 15 cents for which please send me a copy of your current issue; it was all sold out at the newsstand in our town before I could get one."

FRED SIMPSON.

Do your magazine shopping early! Better order your August number from your newsdealer *now.*

* * *

AND here is a personal letter from one of the most widely-known men in the electrical industry who points out one of the really worthwhile duties of an editor—to render a useful public service:

"POPULAR RADIO is bringing to the radio novice and to the radio amateur in terms that the lay reader can understand, sound and authoritative information concerning the electrical science and the radio art—and in this it is rendering a real and invaluable public service."

GEORGE H. GUY, *New York.*

* * *

IN the protection of our readers, all radio equipment that is advertised in this magazine has met and must continue to meet the approval of the POPULAR RADIO INSTITUTE. A more extended notice of the Institute and its investigations will appear in the next issue—August.

* * *

THE leading article in the next number will be "Fighting Fire by Radio," illustrated with photographs that show how the Forest Service is saving Uncle Sam countless thousands of dollars—not only in reporting forest fires but also in directing the work of the fire-fighters.

Editor, POPULAR RADIO

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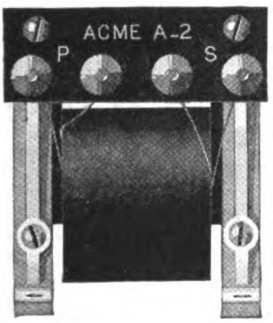
The end of a perfect howl—

THE squawls of a two year old are as music to the ear beside the howling demonstration put up by a fractious radio set. And how a set can howl unless one offers the soothing influence of the proper amplifying transformer.

Most any transformer can amplify sound, but it will also amplify the stray fields which produce howling and distortion. It takes the Acme Amplifying Transformer with its specially constructed iron core and coil to put an end to the howls and yowls. Only when you add the Acme do you get the realistic tone and volume so markedly absent in the ordinary radio receiving set.



Type A-2 Acme Amplifying Transformer, price $5 (East of Rocky Mountains)

The Acme Radio Frequency Transformer greatly increases the range of any receiving set, either vacuum tube or crystal detector type. The Acme Audio Frequency Transformer produces not only volume, but reality of tone. It is indispensable to the satisfactory operation of loud speaking devices. The combination of one or more stages of Acme Radio and Audio Frequency Transformers assures the maximum of range, of volume and of reality in tone.

The Acme Apparatus Company, pioneer radio engineers and manufacturers, have perfected not only Radio and Audio Frequency Transformers as well as other receiver units and sets, but are recognized as the foremost manufacturers of Transmitting Apparatus for amateur purposes. Sold only at the best radio stores. The Acme Apparatus Company, Cambridge, Mass., U. S. A., New York Sales Office: 1270 Broadway.

ACME

for amplification

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HOMCHARGE
YOUR BATTERY
for A Nickel

NO muss, trouble, dirt — no moving of batteries—loss of time — no effort on your part—no technical or professional knowledge needed.

THE **HOMCHARGER**

successfully meets all charging conditions, and is the only rectifier combining the following essential Homcharging features.

1. Self polarizing. Connect battery either way and it will always charge. No danger of reverse charging, ruined battery or burnt out Rectifier.

2. No delicate bulbs to break or burn out. Only one moving and two wearing parts. These are replaceable as a unit, after thousands of hours' use, at small cost. Cannot be injured by rough handling.

3. Operation stops and consumption of current ceases immediately upon disconnecting battery.

4. The only charger costing less than $100.00 that will fully charge a battery overnight. Gives battery a taper charge—exactly as recommended by battery manufacturers. Guaranteed not to harm your battery even though left connected indefinitely.

5. Highest efficiency of any three or six cell charger made.

6. No danger of fire. Approved by the Underwriters.

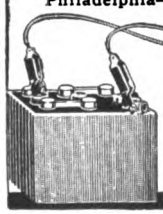
Will charge any Radio "A" or "B" battery as well as your automobile battery. Send for Bulletin No. 58 for further information.

For sale by all radio, electrical and accessory dealers or shipped express prepaid for purchase price $18.50
$20.00 West of the Rockies

The Automatic Electrical Devices Company

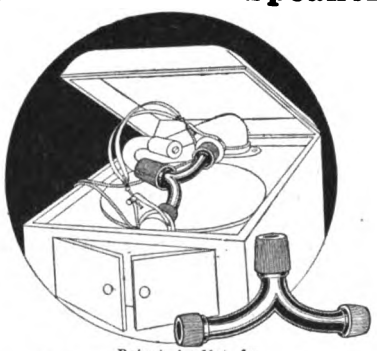
131 West Third Street, Cincinnati, Ohio

Branch offices — New York — Chicago — Pittsburgh—Los Angeles—New Orleans—Detroit—Philadelphia—Baltimore—Dallas.



Largest Manufacturers of Rectifiers in the World

Make Your Phonograph A Radio Loud Speaker



Patent Applied for
PHONOTACH
(Trade Mark)

Here's what you've been looking for—a **NEW AND BETTER LOUD SPEAKER** at a reasonable price. The **PHONOTACH** connects the receivers of your radio outfit with the tone arm of your phonograph. It utilizes the scientifically designed tone amplifier of the talking machine with results that are delightfully surprising. The **PHONOTACH** insures mellowness and beauty of tone. Adjusted in a minute. Get one today.

PRICE $3 COMPLETE
At your dealer's or direct by mail
W. A. MILLS, 103-PR Park Avenue, New York

RADIO INVENTIONS

WE shall be pleased to have you consult us with regard to patenting any new radio equipment which you may develop. Two members of our staff of attorneys, formerly with the Western Electric Company, specialize in patents relating to the radio art.

Office consultation particularly invited.

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Hanna Building . . . . Cleveland, Ohio
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Scientific American Bldg., Washington, D. C.
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IF one of our amateurs should pick up a radio message sent out to us from some planet circling a sun on the far frontiers of the Milky Way he would know that the sender of the message lived and died more than 25,000 *years ago and that the message had been on the way all that time, and this, too, coming at the speed of light—* 186,000 *miles a second. For the light by which we see such a star left there* 25,000 *years ago.*

—HUDSON MAXIM

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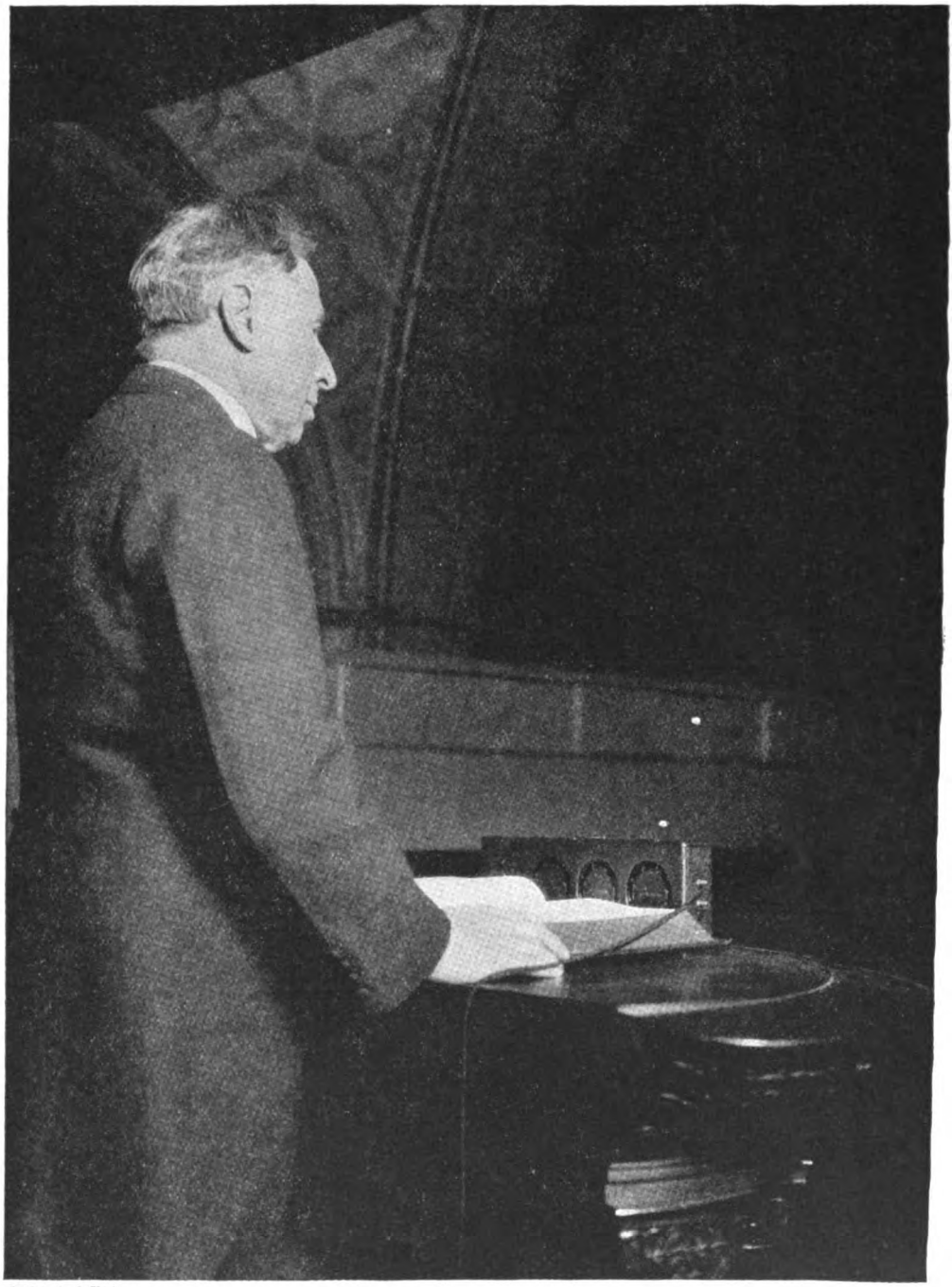

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A SERMON THAT WAS BROADCASTED OVER AN AREA OF 12,000 SQUARE MILES

By means of the four microphones connected in multiple on the pulpit, the voice of Dr. Charles Wood of Washington, D. C., was converted into electrical current that was transmitted by radio from a station in the church loft over a distance of 350 miles in all directions. Is the radio hurting the church? Turn to page 176.

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Popular Radio

VOLUME I JULY, 1922 NUMBER 3

Radio: *the* World's Peace-Maker

Is Wireless Destined to Succeed Where Statesmen Have Failed in Bringing the People of the Earth into Understanding with Each Other? So Thinks the Distinguished World-Correspondent—

WILL IRWIN

IT was two summers ago. Teddy, who lives just behind me in the country, had been exceedingly busy these many weeks. I know young Teddy as a mechanical marvel, and having myself been born without dower of a mechanical sense, I admire his activities without investigation. I did notice him dimly, at different times, in the act of nailing wires along the flagpole, and digging some kind of trench by the back door. Also, I found him at his chum Kilby's making a trade for a worn-out automobile battery.

"Whatever is he up to now?" I asked Kilby.

"Wireless telegraphy," said Kilby.

"Gee, the kid's ambitious," I remarked. As I remember it now, I had heard only recently that you could telephone without wires.

The day of the Carpentier-Dempsey fight arrived, and I was marooned in the country. I was trying to work pending the hour when I should telephone to Boston for news, when Teddy strolled in.

"Want to hear the returns from the fight?" he asked. "Got the old box tuned. They'll be talking from the ringside in ten minutes."

I flew to Teddy's room. He slipped on his headpiece, did some mysterious testing; I slipped on mine. A voice, far clearer and more natural than any I had ever heard over the conventional telephone, was saying:

"Carpentier has just entered the ring!"

When the excitement was over, I expressed to Teddy my fulsome admiration —plucking official dispatches out of the air in that way. Teddy received my compliments modestly. "All the fellows are doing it," he said.

I didn't really believe him. It was only last winter, when the newspapers began to burst out with radio columns, when Hoover held his conference in Washington, when the statisticians announced a million receiving outfits in the East alone, when I found the term "ether hog" embedded in American slang, that I realized how a new force of civilization had been slipped over on my generation. The newer generation is always doing that to the elder, I suppose. Probably along about 1830, middle-aged gentlemen heard with dim interest that people were starting railroads, and noticed next that stage-coaches were beginning to disappear. The

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THE NEW PIONEERS OF PEACE

The average amateur receiving set has a range of about 200 miles. What effect will this have in bringing together the nationalities of crowded Europe?

younger generation is forever remolding the world under our noses; but we have on our reading glasses and cannot see.

I have been speculating of late on this new agency of civilization; I have even tried to make out the slang of the craft in the radio columns. And I am wondering if we have not found this time a thing bigger than we know. A steam-engine turns wheels or lifts burdens. A locomotive draws, an aeroplane carries material things. But this device distributes speech, which is thought made audible, and thought is the basis of everything. Before the war, some expert on transportation calculated that any two given places on the earth's surface were eleven times nearer than they were a century before; hence the necessity for that growth, so marked since the war, from nations to alliances and finally toward some system of general world federation. But here we are in process of bringing all points in the world so close together in this important matter of speech from man to man, that virtually no distance intervenes at all.

I am quite aware—moron though I am in the matter of mechanics—of the mechanical limitations in this stage of development. I know that the million radio enthusiasts on our Atlantic coast are only listeners, not speakers, that the present receiving radius for a set within the means of an ordinary boy is only two hundred miles or so; that we have not solved the problem of unlimited numbers of conversations. However, he who says that all the limitations cannot be conquered rates himself, to my mind, with those who said in 1810 that a locomotive traveling twenty-five miles an hour would kill all its passengers by "air suction" or those who said in 1905 that the aeroplane must always remain a toy and would never fly far. I believe these difficulties will be conquered and then—what a changed world!

To begin with the most important thing: the question before us all is whether we are going to get rid of war or war is going to get rid of us.

Everyone who has struggled with this problem understands that it has a dual nature. We must organize the world in such manner as to have a real international law between nations as we have national law between individuals; and we must back up this law by a real moral sense.

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From a photograph made for POPULAR RADIO

WILL IRWIN LISTENS IN

In the radio he sees something infinitely greater than a mere instrument for entertainment, however. He conceives it as a medium for bringing the scattered peoples of the world into contact and eventually into understanding.

Leagues or associations of nations, tribunals of arbitration, Pacific pacts, will serve but little if peoples keep up those old hatreds and suspicions which result mainly from poor acquaintance—if the average German continues to believe that the average Frenchman is a false, immoral little doll, and the average Frenchman believes that the average German is a wallowing human hog.

I remember an instance which points the moral. Three months after the armistice, I traveled down the Rhine with a commission of French officers. In the party was a young lieutenant, member of a family which owned a famous French printing establishment. He had been brought up in the business; art typography was his hobby. Also, he hated Germans. At Mayence (or Mainz) lived Gutenberg, generally credited with the rediscovery of printing for the western world. In the town museum are kept not only his presses, his types and specimens of his early work, but a library of artistic printing which has been accumulating for four centuries. The lieutenant and I, the only members of the party interested in such things, went A. W. O. L. to visit the museum. We were admitted by the curator, a crop-headed little German with a square set to his shoulders, a red scar across his scalp and a barking voice. Every line and tone and gesture proclaimed that he was an ex-officer of the late Imperial army. The Frenchman saluted formally; the German clicked his heels and bowed stiffly. We moved to the collection in an atmosphere of frigid hate, badly veiled with overdone politeness. And so we plunged into Gutenberg and into exchange of views on printing. When, four hours later, we left the Museum, the Frenchman and German shook hands enthusiastically, and both of us visitors had joined the Gutenberg Soci-

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WILL THE AMATEURS BREAK DOWN INTERNATIONAL BOUNDARIES?

These school boys at Haslemere, England, are doing something more than merely rigging up an antenna on an old wind mill; they are laying the foundations for a radio acquaintance with schoolboys in France and Germany and Italy —and perhaps some day in America.

ety! The bond of common intellectual interest is stronger than the bonds of race.

So, in the next generation the average German of Nuremberg, say, may remember, as war clouds the horizon, that French boy of Tours with whom he used to discuss every night his butterfly collection or his stamps or his troubles with his wireless apparatus. And it will not be possible to make him believe with conviction that every Frenchman is an effeminate little rat. And similarly the Frenchman, remembering Hans, the ether-chum of his youth, will not swallow the idea that every German wallows in blood. That is the boy end of it—wireless telegraphy, glory be, is primarily a boy-activity. And because the thoughts of youth are long thoughts it is also the important end. But men too will be speaking nightly with men of similar tastes. "How can I hate a man I know?" said Charles Lamb.

All this, provided we overcome the language barrier. And there comes another fascinating possibility. All my generation, certain enthusiasts have been inventing and trying to implant a universal language. The Esperantists showed how simple a language could be made. Strip it of grammatical irregularities and idioms, construct its vocabulary so far as possible from those roots common to all the European tongues, and you have a language in which any person of average intelligence ought to become proficient in a few weeks. Indeed, people especially gifted in the language faculty have learned a good speaking knowledge of Esperanto in a week. But none of these projects "took hold;" Esperantism remained the tongue of a few enthusiasts. There was lacking a pressing need—the only thing which urges men on to great changes of habit. The need is here.

Who knows but in the days of my grandson every school of standing will be teaching along with the native tongue a tongue universal? And if that comes about—all it will mean for peace and international understanding—we shall owe it solely to the wireless telephone.

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General Electric

There Are No Ether Waves

A New Conception of Radiant Energy That Disposes of Many Present Day Theories

By Dr. Charles P. Steinmetz

THE author of this article—who is not only a great electrical engineer and the Chief Consulting Engineer of the General Electric Company but also one of the greatest physicists of the world—does not believe in ether waves. Science, he says, has disproved the real existence of any material substance like the ether. In this statement he reflects the most recent scientific conclusions on the subject. Light and radio waves are merely properties of an alternating electromagnetic field of force that extend through space.

Scientifically this is conclusive. Professional scientists do not need the idea of the ether. They can think better without it. They can think better in terms of an electromagnetic field.

For non-scientific readers this may not be so easy. The idea of a field of force is not easy to grasp. Perhaps it will be necessary for a while, for beginners to retain the understanding of radio effects by the ether hypothesis—to think of light and other radiations as being waves in something, waves like waves in the water.

To science the ether hypothesis is useless. In helping the mind to get a preliminary idea of radio, it may still be of service. Just as it is convenient to keep on thinking of gravitation as a force between two pieces of matter, although the Einstein theory of relativity has shown that gravitation is neither a force nor energy nor a property of matter, but is, apparently, a property of space.—Editor

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THE greatest contribution to science of the last ten or fifteen years, in my opinion, is the theory of relativity as worked out by Einstein and his collaborators. It is of vital importance because it revolutionizes our whole conception of nature and space. The theory of relativity concludes that there exists no absolute position or motion, but that these elements are relative.

In other words, if we had only one single body in the universe we could never know whether that body is moving or standing still. If we had two bodies we could never find out whether body A moves and body B stands still, or whether body B moves and body A stands still. Nor could we determine whether they both move. There is no real absolute motion and we can speak of motion as relative only. If we had only one body in other words there would be no reason in speaking of that body as either moving or standing still. The conception of motion comes in only when there is more than one body.

This conclusion is incompatible with the hypothesis of the ether as carrier of light.

If ether fills all space, then there must be absolute position and absolute motion. A body is at rest or is moving relative to the ether, and this would be an absolute motion and would enable us to find out whether the body is standing still in regard to the ether or whether it is moving in regard to the ether, even if no other body existed.

If the theory of relativity is right, therefore, then there can be no such thing as the ether and the ether hypothesis is untenable. It becomes necessary, then, to look into this ether hypothesis to determine how it was evolved and what it means.

The first theory of light which demanded attention was promulgated by Newton. He explained light as a bombardment of minute particles projected at extremely high velocities. If this corpuscular theory of Newton's is right, then two equal beams of light when superimposed, must always combine to a beam of twice the intensity. Experience shows, however, that two equal beams of light, when superimposed, may give a beam of double intensity or they may extinguish each other and give darkness, or they may give anything between these two extremes. This can be explained only by assuming light to be a wave, like an alternating current. Depending on their phase relation the combination of two waves, as two beams of light or two alternating currents, may be anything between the sum and the difference of the two intensities. Thus two alternating currents which are in phase add; if they are out of phase they subtract.

If light is wave motion, there must be something to move, and this hypothetical carrier of the light wave has been called the ether. At this point our troubles begin.

The phenomenon of polarization shows that light is a transverse wave; that is, the ether atoms, or whatever it is that moves in the ether, move at right angles to the light beam, and not in the direction of the beam as is the case with sound waves. In such transverse motion, a vibrating ether atom neither approaches nor recedes from the next ether atom, and the only way in which the vibratory motion of each ether atom can be transmitted to the next one is by forces that act between the ether atoms so as to hold them together in their relative position. That is, transverse waves can exist only in solid bodies. As the velocity of light is extremely high (180,000 miles a second) the forces between the ether atoms, which transmit the vibrations, must be very great.

In other words, the hypothetical ether is a solid with a very high rigidity—infinitely more rigid than the hardest steel.

At the same time the ether must be of extremely great tenuity, since all the cosmic bodies move through it at high velocities without meeting any friction. In the revolution of the earth around the

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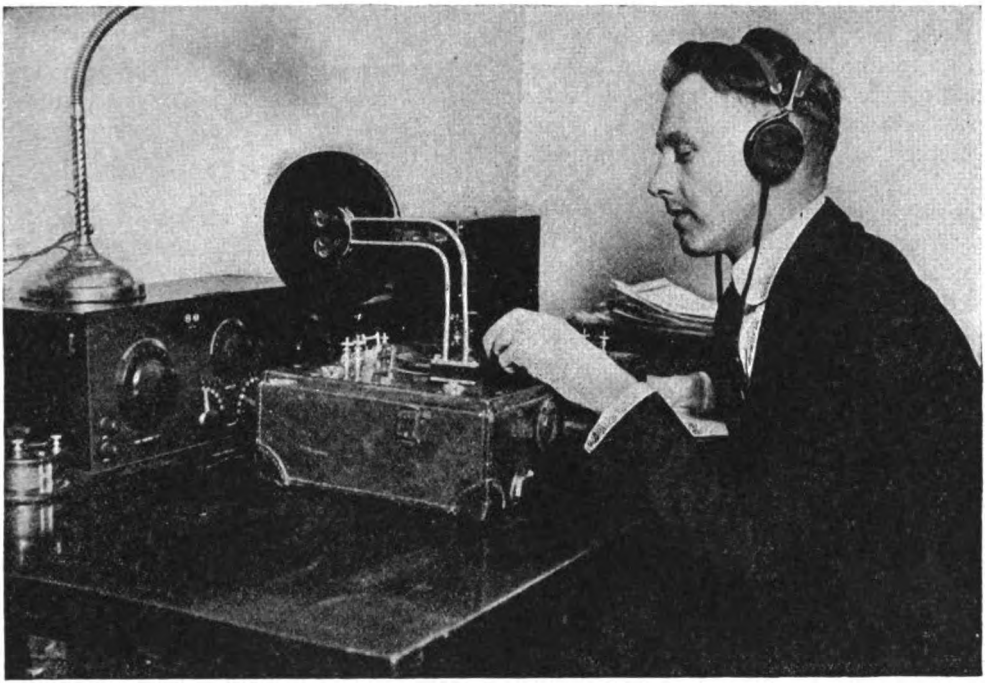

International

DO WAVEMETERS REALLY MEASURE "ETHER WAVES?"

If, as Dr. Steinmetz maintains, there is no such thing as ether there are obviously no such things as ether waves. Accordingly this machine, instead of recording lengths of ether waves, must be recording some other forms of resonant phenomena which do not rest upon the ether hypothesis.

sun either the ether stands still and the earth moves through the ether at twenty miles a second, or the earth carries a mass of ether with it. In the first case, there should be friction between the mass of the earth and the ether; in the latter case, there would be friction between the ether that is carried along with the earth, and the stationary ether. But in either case, the frictional energy would come from the earth and show astronomically as an increase of the length of the year and increase of the solar distance. And no such evidence of ether friction is observed.

The conception of the ether is one of those hypotheses, which have been made in the attempt to explain some difficulty, but the more it is studied, the more unreasonable and untenable it becomes. It is merely conservatism or lack of courage which has kept science from openly abandoning the ether hypothesis. Belief in an ether is in contradiction to the relativity theory, since this theory shows that there is no absolute position nor motion, but that all positions and motions are relative and equivalent.

Thus the hypothesis of the ether has been finally disproven and abandoned.

There is no such thing as the ether. And light and wireless waves are not wave motions of the ether.

What, then, is the fallacy in the wave theory of light, which has led to the erroneous conception of the ether?

The fact that beams of light can cancel out each other, and can interfere, proves that light is a wave, a periodic phenomenon, just like an alternating current. Thus, the wave theory of light and other radiations stands today just as unshaken as ever. However, when this theory was established the only waves with which people were familiar were the waves in water

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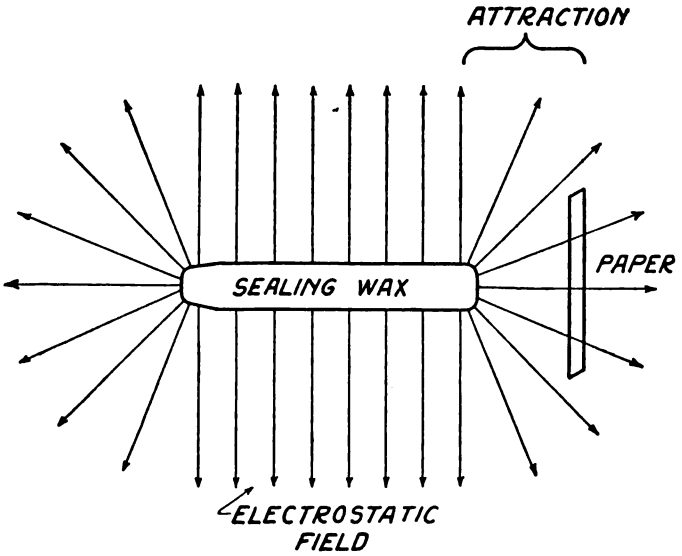
and sound. Both are wave motions. Waves involving movement of matter. As the only known waves were wave motions, it was natural that the light wave was also considered as a wave motion. This led to the question; what moves in the light wave? And this question led to the hypothesis of the ether, with all its contradictory and illogical attributes. But there is no more reason to assume the light wave to be a wave motion of matter than there is to assume the alternating current wave to be a motion of matter. We know that nothing material is moving in the alternating current, and if the wave theory of light had been propounded after the world had become familiar with electric waves of alternating currents, that is the waves of periodic phenomena (which are not wave motions of matter), the error of considering the light wave as a wave motion would never have been made and the ether theory would never have been propounded.

Hence, the logical error, which led to the ether theory, is the assumption that a wave must necessarily be a wave motion. Electrical engineering has dealt with alternating currents and voltage waves; it has calculated their phenomena and applied them industrially, but it has never considered that anything material moves in the alternating current wave and has never felt the need of an ether as the hypothetical carrier of the electric wave. When Maxwell and Hertz proved the identity of the electromagnetic wave and the light wave, the natural conclusion was that the ether is unnecessary also in optics. But curiously enough, we then began to talk about electric waves in the ether and about ether telegraphy. In other words, we dragged the conception of the ether into electrical engineering, where it never had been found necessary before.

But, if the conception of the ether is unnecessary what are we to think of as the mechanism of the light wave and the electromagnetic wave?

Suppose we have a magnet. We say that this magnet surrounds itself by a magnetic field. Faraday has given us a picture representative of the lines of magnetic force. Suppose we bring a piece of iron near this magnet. The iron is attracted or moved. A force is exerted on it. We say that the space surrounding



This diagram illustrates an electrostatic field that is set up around a piece of sealing wax by rubbing it with a bit of cloth, thus attracting such objects as pieces of paper, for example. This phenomenon does not rely upon the ether theory for explanation, states Dr. Steinmetz; it is explained on sounder scientific grounds.

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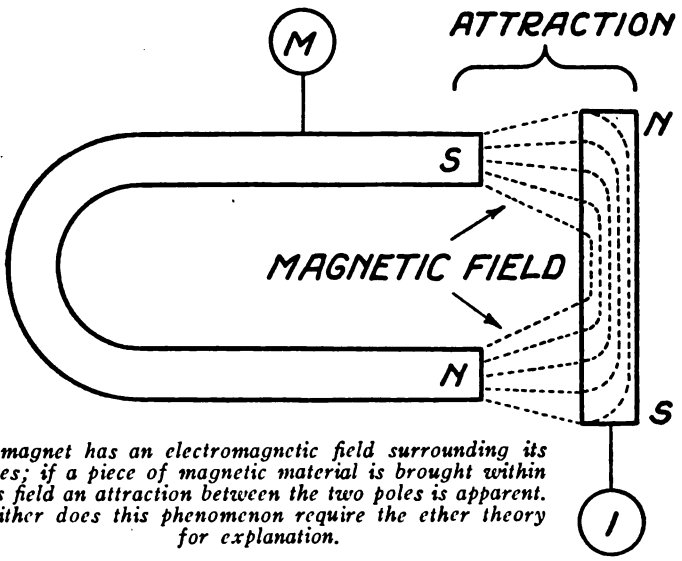

A magnet has an electromagnetic field surrounding its poles; if a piece of magnetic material is brought within this field an attraction between the two poles is apparent. Neither does this phenomenon require the ether theory for explanation.

the magnet is a magnetic field. A field, or field of force, we define as "a condition in space, exerting a force on a body susceptible to this field." Thus a piece of iron being magnetizable—that is, susceptible to a magnetic field—will be acted upon. A field is completely defined and characterized at any point by its intensity and its direction.

To produce a field of force requires energy, and this energy is stored in the space we call the field. Thus we can go further and define the field as "a condition of energy storage in space, exerting a force on a body susceptible to this energy."

The space surrounding a magnet is a magnetic field. There are other kinds of fields of force. For instance, if we electrify a piece of sealing wax by rubbing it, it surrounds itself by a dielectric or electrostatic field, and bodies susceptible to electrostatic forces—as light pieces of paper—are attracted.

So the earth is surrounded by a gravitational field. If a stone falls to the earth, it is due to the stone being in the gravitational field of the earth, and being acted upon by it.

Now suppose that, instead of our permanent magnet with its magnetic field of force, we have a bundle of soft iron wires, surrounded by a coil of insulated copper wire, and that we send a constant direct current through this coil. We then have an electromagnet, and the space surrounding the magnet is a magnetic field. If now we increase the electric current, the magnetic field increases; if we decrease the current, the field decreases; if we reverse the current, the field reverses. If we send an alternating current through the coil the magnetic field alternates, that is, the field becomes a periodic phenomenon or a wave: an alternating magnetic field wave.

Similarly, by connecting an insulated conductor to a source of voltage we produce around it an electrostatic or dielectric field; a constant field, if the voltage is constant, an alternating dielectric field, (that is, a periodic or wave phenomenon), if we use an alternating voltage.

Magnetic and electrostatic fields are usually combined, since where there is a current producing a magnetic field there is also a voltage producing an electrostatic field. Thus the space surrounding a wire that carries an electric current is an electromagnetic field, that is, a combination of a magnetic field and an electrostatic field. If the current and voltage are constant, the electromagnetic field is constant. If the current and voltage al-

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ternate, the electromagnetic field alternates; that is, it is a periodic field or an electromagnetic wave.

Maxwell deduced mathematically, and Hertz demonstrated experimentally that the alternating electromagnetic field (the electromagnetic wave), has the same speed of propagation as a light wave. It has been shown that the electromagnetic wave and the polarized light wave are identical in all their properties. Hence light is an electromagnetic wave.

Electrophysics has been successfully developed to its present high state, has dealt with alternating currents, voltages and electromagnetic fields, without ever requiring a medium such as the ether.

The conception of the field of force, or as we should say more correctly the field of energy, thus takes the place of the conception of the ether. The beam of light, the wireless wave, any electromagnetic wave is a periodic alternation of the electromagnetic energy field in space. Differences between light and other waves are merely those due to differences of frequency. Thus the electromagnetic field of the 60-cycle transmission line has a wavelength of

$$\frac{3 \times 10^{10}}{60} \text{ cm} = 5000$$

kilometers. The field is limited to the space between the conductors and their immediate surroundings. This is extremely small compared with the wavelength. Under these conditions, the part of the electromagnetic energy which is radiated into space is extremely small —so small that it can be neglected. In radio communication we use wavelengths of 15,000 to 200 meters and less; that is, frequencies of 20,000 to 1½ million cycles and more. The circuit is arranged to give the electromagnetic field the greatest possible extent, as it is the field which carries the message. Then a large part, even a major part, of the energy of the electromagnetic field is radiated. The frequency of the light wave is much greater still, 600 millions of millions of cycles. The wavelength, 50 microcentimetres, is a very tiny part of the extent of the field. Therefore practically all of the energy of the field is radiated; none is returned to the radiator.

Our lack of familiarity with the conception of an energy field in space, and our familiarity with the conception of matter as the carrier of energy, may lead to the questions: What is the carrier of the energy of the field of space? Would not the ether be needed as a carrier of the field energy, just as on the older theory it was needed as a carrier of the hypothetical wave motion of matter?

These questions are due to a mental error. Familiarity reverses the relation between primary and secondary conceptions.

All that we know of the world is derived from our senses. They are the only real facts; everything else is conclusioned from them. All sense perceptions are due to energy; they are exclusively energy effects. In other words, energy is the only real existing entity. It is the primary conception, a conception which exists for us only because our senses respond to it. All other conceptions are secondary conclusions, derived from the energy perceptions of our senses. Thus space and time and motion and matter are secondary conceptions with which our mind clothes the events of nature.

Obviously, then, by carrying the explanation of light and electromagnetic waves back to the energy field—to energy storage in space—to the electromagnetic field, we have carried it back as far as possible. We have carried it back to the fundamental conceptions of the human mind; the perceptions of the senses.

¶ *In the next issue—August—will appear the article by Dr. E. E. Free, "How the Sun Helps Wireless," which has been held over from this number in order to include some new and valuable material that is being prepared epecially for* POPULAR RADIO.

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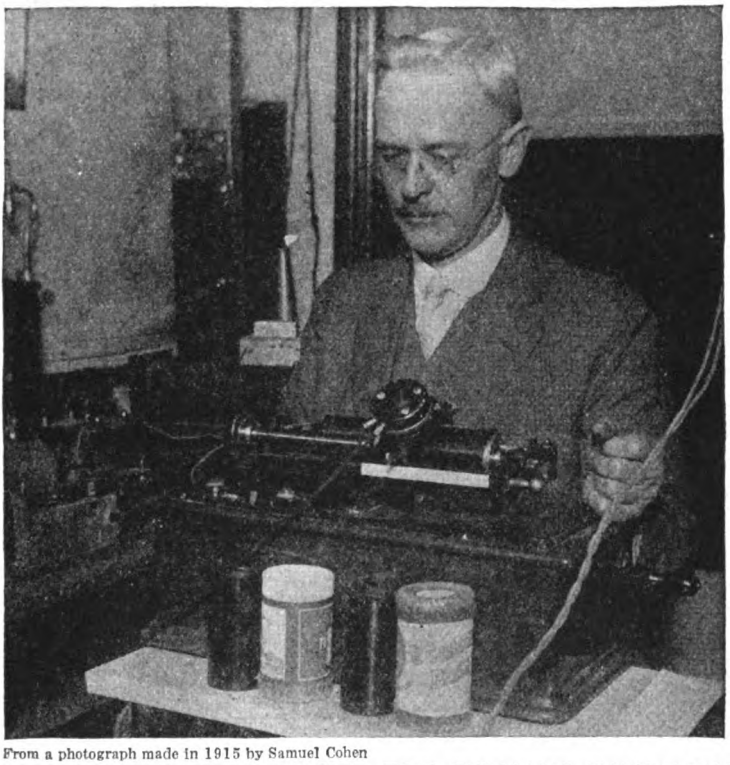

From a photograph made in 1915 by Samuel Cohen

A RADIO AMATEUR WHO BALKED THE GERMANS SINGLE-HANDED

One of the most valuable services ever rendered by a radio operator in this country was performed by Charles E. Apgar, who made phonograph records of the mysterious code messages sent out by the Telefunken station—and furnished evidence that compelled the Government to take it over.

The Secret Service *of* the Air

How the police are beginning to use radio in running down crooks was told by Fred C. Kelly in the June number of this magazine. In this article the author (who prefers to remain anonymous) describes how the crooks themselves are using wireless—and how they have been caught at their own game.

By ONE OF THEM

A TOURIST, clad in white, perched upon the edge of the dock at Nassau and dangled a fishing line through the glass-clear water. Near at hand—within earshot in fact—a schooner much in need of a coat of paint was moored to the dock among other even more weather-beaten craft. With West Indian disregard for time, black stevedores were loading cases upon the schooner, as they had been doing for days past; likewise for days past the tourist had been fishing at the same spot. But his eyes, shaded by the broad Panama hat, watched every movement on the dock or schooner. And when the final case had been placed aboard the schooner, her crew started to strip the covers from her furled sails.

The tourist rose, strolled up the street and ten minutes later from the big wireless towers a message was speeding through the air. It was an innocent enough message, evidently of no great importance. It read:

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"Hendryx, Washington. Helena leaving. Try meet her on arrival. She has considerable baggage."

The secret service of the air was at work. It was doing its bit to stop the influx of contraband liquor from the Bahamas. But even the secret service of the air is not always infallible.

* * *

A few days later, upon a smooth sea, with Martha's Vineyard just out of sight below the horizon, a speedy looking schooner much in need of a coat of paint lay hove-to, rolling gently to the Atlantic swell, a blue triangular flag at her main topmast head.

Presently, in the direction of the land, a tiny white speck appeared which developed into a rushing power boat, her brass work gleaming in the sun and her mahogany cabin glistening with varnish. At the boat's wheel was a uniformed officer and another yachtsman; at the summit of the craft's single mast there streamed a triangle of blue.

International

EAVESDROPPING BY RADIO

When the San Francisco police raided a local bucket shop they found this miniature radio apparatus for receiving stock tips transmitted by a confederate in a broker's office that had wire communications with the N. Y. Stock Exchange.

Upon the schooner's deck a bull-necked man gazed at the oncoming yacht through his glasses.

"That's him," he remarked and gave an order to a mulatto standing near. A moment later, a tiny ball rose upward to the schooner's trucks and broke out into a square of white bunting. Immediately upon the power boat's mast there appeared a red triangle beneath the blue. Fifteen minutes later, the yacht was motionless fifty yards from the schooner and a rowboat was dancing towards her.

A few nights later a small schooner, much in need of a coat of paint, was headed towards the inner harbor of New York under her rickety gasolene kicker. A police boat fell in behind the slowly chugging little schooner, trailing in her wake until she at last turned up the East River and dropped anchor off a recreation pier under the shadow of Queensboro bridge.

But on that silent run up the harbor the secret service of the air had not been idle. Lurking about the pier, crowded in the shadows, were armed men. The *Helena* would indeed be met at the dock and her baggage well looked after! And there were others there too. Motor cars and trucks were parked near the dock, as if awaiting loads; most of them had their engines running. The waiting officials and police figuratively patted themselves on their backs. There had been no hitch in their plans; the schooner was in the stream; the trucks were awaiting her cargo.

Presently, from the river came a sharp whistle—three short blasts and a long one. From a waiting car came the reply. A moment later, the staccato exhaust of the craft's motor echoed over the river

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and the schooner came slowly alongside the dock. Scarcely were her hawsers made fast when the hidden men swarmed over her bulwarks like old-time buccaneers boarding a prize. A few seamen exchanged blows with the raiders; a bull-necked man swore a bit, and all was over. An hour later the heavily loaded motor trucks were rumbling through the streets with armed men beside the chauffeurs and a patrol wagon was carrying a bull-necked man with several of his fellows to a police station.

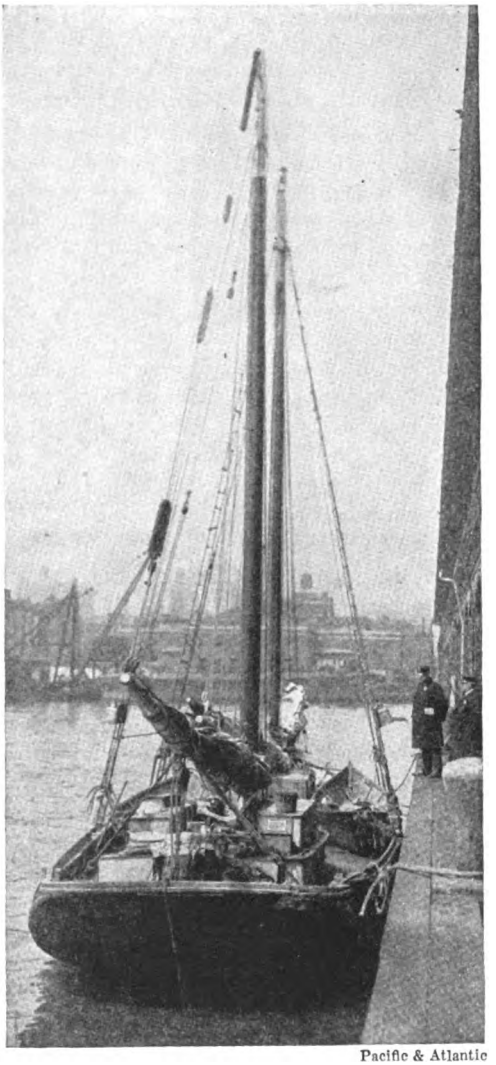
The following morning, however, the bull-necked man and his fellows walked forth from their enforced quarters of the previous night. Disgruntled prohibition officers glared after them as they tumbled over the bulwarks of their schooner, cast off the hawsers and with spluttering motor headed down the river.

Within the cases, boxes and kegs that had been seized there was not a drop of liquor. Nothing but plain sea water and unfermented cane juice!

But in another part of the city a few men, just returned from a cruise in a fast power boat, sat in a luxuriously furnished apartment and joked as they read the accounts of the schooner's seizure. Safe from prying eyes, they had stored enough of the real liquor to keep them supplied with luxuries for many weeks.

On this occasion the secret service of the air had lost, but such are ever the fortunes of war. Constantly, day and night, week after week and month after month, a battle of wits is being waged between officers of the law and law-breakers—and both sides are using the secret service of the air.

Few people realize what an important part radio has played in apprehending criminals; few realize what a tremendous part it played in the war; fewer still realize its possibilities and its limitations. And, although it is the easiest of means for transmitting secret messages, at the same time it is the most difficult means for keeping anything secret. A message hurled through space by wireless is everyone's property and the code has never yet been invented which cannot be decoded. Moreover, a law-breaker who hears a code message or even one which savors of a hidden meaning, at once is on the alert. Guilty consciences make keen wits and suspicions are at once aroused. The simplest and apparently the most innocent message may carry a hidden meaning which no one could ever suspect.



Pacific & Atlantic

CAPTURED ON A TIP VIA WIRELESS

Not all schooners seized by the excise officers carry liquor; sometimes the rum-running plan to let the authorities get false tips by radio and run down a decoy vessel that carries no contraband at all!

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During the war, code messages often gave way to apparently plain, everyday messages which readily passed the censors. Now and then some little peculiarity, some chance or coincidence or some "hunch" aroused suspicions; still, thousands of radio and cable messages with concealed meanings passed in and out. Remarkably clever were many of the ways in which this was done, too.

There, for example, was the case of the German messages, a meaningless, musical hum or buzz which puzzled all hearers, which meant absolutely nothing and which caused endless annoyance in 1914 and early in 1915. With the tremendous power of the great Nauen station behind it, the musical note, like the buzzing of a titanic bumblebee, sped through space.

At the same time a somewhat similar phenomenon was observed by radio operators in connection with the large radio transmitting station of the Atlantic Communication Company (generally known as the "Telefunken Company"), located at Sayville, Long Island. In the words of L. R. Krumm, who at the time was Chief Radio Inspector of the Bureau of Navigation in New York, his staff noticed that shortly after the declaration of war in August 1914, "Sayville station was sending and receiving a considerable number of extraneous messages not considered part of the regular traffic, which was supposed to be in plain English." The mystery was brought to the attention of William J. Flynn, Chief of the U. S. Secret Service, but the strange signals and buzzes could not be deciphered. Was the Sayville station sending information to the Germans? The matter looked serious.

But Uncle Sam's secret service of the air were not the only ones to note the Sayville signals. Over in Westfield, New Jersey, a keen-witted radio amateur, Charles E. Apgar, had also been studying them on his own account. Every night at eleven o'clock he had noted that the Sayville Station had called POZ—which was the great radio station in Nauen, Germany. Upon establishing contact, the Sayville Station proceeded to communicate with an incredible speed—so rapid as to make the messages unintelligible.

Mr. Apgar got an idea. He had been experimenting successfully as far back as 1913 in recording radio signals on wax phonograph records. To do this he had developed an amplifying apparatus of a highly ingenious nature that he called an "ampliphone"—an apparatus that enabled him to read radio messages at a distance of 600 feet from his house. Why not make phonograph records of the Sayville signals and study them at his leisure?

He did so. But no sooner had he gotten started on this self-imposed task, however, when he received a summons from Mr. Krumm, who introduced him to William J. Flynn. The next day Mr. Apgar was pursuing his investigations for the U. S. Secret Service. On June 7, 1915, he picked up his first phonographic record of the Sayville radio signals. For two weeks he labored, during which he piled up scores of wax cylinders. This canned evidence was then delivered to the government authorities.

Perhaps in poring over these transcriptions the motor of the phonograph ran down, and as the wax cylinders revolved more slowly the "buzz" became disintegrated and resolved itself into distinguishable code signals. At any rate, Mr. Apgar's wax records revealed vital information — and the Sayville station was promptly taken over by Uncle Sam. And it was a radio amateur who did it—admittedly one of the most valuable services rendered by an individual during the war.

Both the Germans and the Allies used innumerable methods for transmitting secret messages; many of the most effective of these did not die with the cessation of hostilities. Some of them were adopted by law-breakers as well as by law-abiding persons when they wished to communicate without letting others know what was being said. It would surprise the average person to know how many and how simple are the available means

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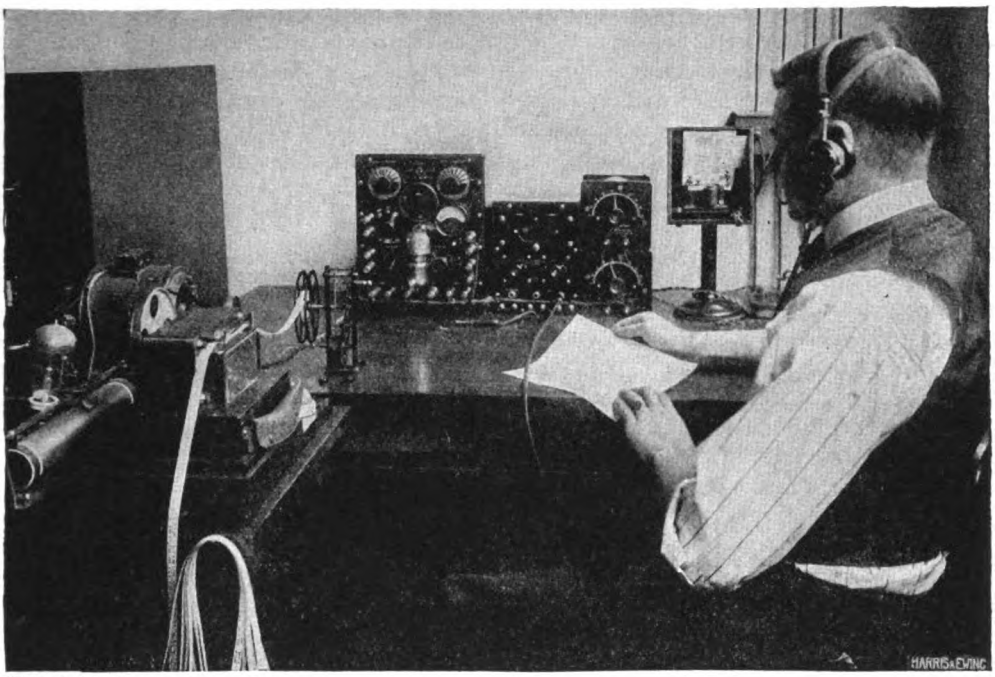

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IT IS EASY TO SEND SECRET CODE MESSAGES BY RADIO ON TAPE MACHINES

The dot-and-dash system, by which letters and figures are indicated by transmitting apparatus that punctures paper strips, may be readily manipulated to convey undecipherable meanings to those who are not in the secret.

of sending secret messages. Despite popular ideas, codes or cryptograms are neither the most commonly used nor the safest. Of course, any message with a hidden meaning is a code message; the fact that such codes are not recognizable as codes make them the most difficult to detect or to decipher.

Who, for example, would suspect anything out of the ordinary in a radiogram stating that a cargo of sugar had been shipped and that the bills of lading were going forward by hand? And who would guess that another message announcing the birth of a child and stating it had been christened Mercedes would have any hidden meaning? Such messages passed the censors without question yet by a coincidence which, if used in fiction, would be scoffed at as impossible, these innocent-appearing messages led to the apprehension of the most dangerous and long-sought criminals.

Wholly by chance, a quiet man whose secret mission was unknown outside of a scant half dozen officials, happened to be a passenger upon the very ship by which this sugar was supposed to be forwarded. By an even more remote coincidence, he saw the innocent appearing message. Instantly his suspicions were aroused, for he had watched the steamer's cargo going aboard and he knew there was no such shipment. The rest was easy. "Sugar" meant important information; the "bills of lading" meant documents and the message from a fond and proud parent announcing the "arrival of a daughter" was nothing more or less than a tip as to when the bearer of the letters sailed and her name.

That time the secret service of the air scored against the enemy.

While such a method of communication is perhaps the safest and most secretive, it is not a simple nor a satisfactory way to carry on a secret correspondence in cases when messages must be frequently

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interchanged. Elaborate codes of double meanings must be prearranged and the messages must present a natural appearance with apparent sense to them. To invent messages which appear natural and which are composed of words with double significance is no child's play. For a brief time they may pass unquestioned; but sooner or later some lynx-eyed man may wonder why certain unusual words recur so frequently and an investigation will result—usually with unfortunate results to the conspirators. It is practically impossible to prevent messages by radio from reaching their destination or to prevent secret messages from being received by those for whom they are not intended. Anyone can receive; only a house-to-house daily search could put the lid effectively upon receiving by radio. With indoor and loop aerials the enemy is perfectly safe; he can hear every message that speeds through the ether. During the war, all amateur and private wireless stations were closed. Because the government did not wish its messages to be heard? Not a bit of it. Our officials never for a moment deluded themselves with the idea that they could prevent messages from being heard. But to prevent messages from being sent.

Uncle Sam could censor, hold up, destroy or forbid messages by telegraph, cable or mail—but not by radio. If any radio messages were permitted to go out, all who listened could hear them; there was no censorship, no control possible except by closing all sending stations—and even that was impossible. If a spy or a criminal wanted to send a radio message he could send it and did send it. Not on a large scale to be sure. But there was nothing to prevent him from setting up a station, getting his message or information off and hastily vacating the vicinity. And there was many a warning sent through the ether in just this way. But during time of war it is far easier to control the air than in times of peace.

The means of getting secret radio messages through without detection are almost unlimited; a force of trained men constantly at work would be necessary to keep pace with the schemes put into practice by men, who, if they turned their brains and inventive ability to legitimate channels, would make fortunes. It is said, (although I am not sure that it was ever demonstrated), that the Germans devised a method of sending out radio waves of such incredibly high frequency that no ordinary set could receive them; that even after being reduced by detectors they were still too rapid to produce a vibration in the receiver that was decipherable; only by means of special apparatus designed for their reception could the code be caught.

But the majority of devices for carrying on an aerial secret conversation are far simpler and less spectacular than anything of that sort. Specially designed typewriters, in which the type bars do not carry the letters corresponding to those on the keyboard can be used to produce messages which are almost beyond the possibility of decoding, yet the other party to the scheme, merely by typing off the message on a machine in which the letters are reversed, can translate the hodge-podge of letters into a legible message.

On one occasion while in Europe I received a radio code message which could not be decoded. At least, all the experts in London, including the naval and military intelligence officers, the Admiralty experts and the inventors of innumerable codes, could make nothing of it. Yet it was the simplest code in the world—once you knew the key.

I had left word with a friend to use a certain well known commercial code when communicating with me. The first message I received was not in this code and I could not decipher it. In vain I took it to every office of the published commercial codes; every expert shook his head and declared it was not like anything he had ever seen. Meanwhile my friend was on the high seas out of reach and for many months the message remained a curiosity, one of the few mes-

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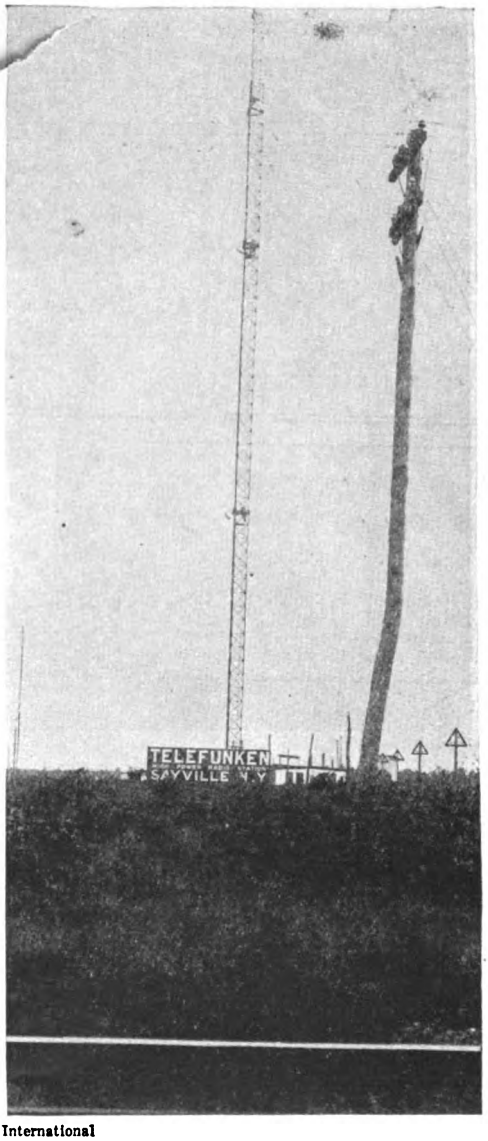
sages which had baffled British and American officials alike.

When I at last returned and met the sender my first question was, "What code did you use with that message?"

He replied that he had used the one I had designated and to prove his statement he produced the book he had used. The book was a maritime edition of the code and the words my friend had used were the combinations of letters representing signal flags to be flown when sending signals corresponding to the commercial code words. In other words, my innocent friend had used a code within a code which could only have been deciphered by running up the corresponding flags and translating the code from them. Here, once more, mere chance had played an important part and I wondered that some one had not stumbled on the idea before.

Another means of using the code is to use a specially prepared and arranged tape-punching machine which will produce a special tape for sending. When the dot and dash messages are sent from the big stations the operator does not tap off the dots and dashes on a key, as does the operator in a country railway station. Instead, the message received from the sender is copied on a typewriter-like machine which bears groups of dots corresponding to letters upon its type bars. When a letter is struck, a tape is perforated with dots. Then this perforated tape is run through a sending machine that is provided with metal fingers which make contacts through the perforations in the tape and automatically send the message vibrating through the ether at far greater speed than any human hand and brain could tap it off on a key. On the ordinary tape, two dots, one above and one below a central line, signify a code dot while one dot above and one below but slightly out of line vertically mean a dash.

But there is nothing to prevent a person so disposed from altering this conventional arrangement. Suppose it were prearranged that one dot directly above another meant a dash, that two dots out of line meant a dot and that two dots close together meant two dashes or anything else. Such a tape would produce messages which, when recorded on the receiving machine, would present an ir-



International

CLOSED BY THE "SECRET SERVICE OF THE AIR"

The famous transmitting tower at Sayville that once held mysterious radio communications with Nauen, Germany, every midnight—until its mystery was solved by a peer of Sherlock Holmes.

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International

THE POLICE OF PARIS USE THE RADIO ON THEIR MOTOR VANS

On May 1st—the day observed by the radical elements—the Prefect of Police of Paris experimented with radio-equipped motor vehicles that enabled the authorities scattered at different points about the city to keep in communication not only with headquarters but also with officers in a police airplane, as an aid in directing the crowds that participated in the May Day demonstrations. The Prefect is the portly gentleman in the derby hat at the right of the picture.

regular or serrated line which at first glance would appear to be an ordinary message, but which would be meaningless to those not in the secret.

Endless variations are possible in this way and have proved one of the greatest puzzles to the secret service of the air. Indeed, the dot and dash codes have always provided a most easy and simple means of secret communication. A prisoner tapping out the dots and dashes in his cell, may readily talk with his fellows and this is a well known and widely practiced means of communication among convicts in prisons.

If a person desires to communicate with another by conversing over a radio 'phone it may be done and is being done in such a way that the most secret matters are spoken of freely. It is only necessary to choose the time, the hour when the big broadcasting stations are sending out their nightly programs, and by using waves of a different length few will hear what is being said. Nearly every one will be tuned to the 360 meter waves and attention will be devoted to the music, songs or baseball returns. Even if some amateur or beginner hears the conversation no heed will be given to it—there are far too many more interesting things in the air for that. Sometimes the very frankness of such conversations is their greatest safeguard. If there is nothing suspicious about two people talking, suspicions will not be aroused, and it is just as easy to have a prearranged code of double meanings for spoken words and sentences, for questions and answers, for casual remarks, for numbers and names

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as for written words. No one knows or can even guess how much plans for hold-ups, burglaries, rum running and other dark deeds may be transmitted nightly by radio.

Next time you are listening to a broadcasting station, tune your set to shorter waves and see how many people you hear talking. If you have never tried it you will be surprised; while you may not hear a word of interest the chances are that something you hear—if you knew its real import—would be vastly interesting to a small army of guardians of the law. Or again, you may hear a conversation which seems pure jargon, a meaningless hodge-podge of numbers, names and words. In that case you may be sure that a secret message is being given.

Radio has been a means of enjoyment to thousands; it has spread like wild-fire through the land. But there was never a crook yet—a really dangerous crook—who was not up to the minute in availing himself of the latest inventions as a means to defeat the law. And radio has been and is a boon to law-breakers as well as to peaceful and law abiding citizens. No wonder it is a difficult undertaking the government has set itself to enforce the prohibition laws. With radio linking boats at sea with shore, warnings and any other information may be sent back and forth between the smugglers' craft and confederates ashore and the secret service of the air cannot prevent it.

Not long ago, a certain man was listening at his set, tuning his instrument to pick up any messages which might throw light upon a plot which, he was led to believe, had been largely carried on by radio. Scattered in various places, there were probably fifty more of his kind doing the same thing.

Night after night they had been doing this, one man constantly at the receivers; yet nothing had been heard which they could lay hands upon.

Nothing? Yes, there had been something. Over and over again, a voice had been heard making commonplace remarks; at times mentioning names and numbers. There was nothing suspicious about his voice—but he was apparently talking to himself!

Of course his words were taken down and hours were spent poring over them in attempts to decipher his conversations. But to no avail.

Then, by one of those strange chances, the puzzle was solved. One of the secret listeners-in grew weary of the fellow's one-sided chatter. He breathed a sigh, stretched his cramped limbs and, as he did so, one arm came into contact with a desk telephone near at hand. Instantly, the man was all attention, for where only one voice had been heard before, now there were two! It was no longer a one-sided conversation; a man and a woman were talking!

To the layman the phenomenon would have seemed incomprehensible, but it was simple. The woman, having no sending set, was talking over an ordinary telephone to the man who, listening to her words with ordinary telephone receivers and was talking to her over his radiophone, while she was receiving his words on her receiving set. Only by the chance touch of the listener's arm was the puzzle solved when, through the capacity effect of the human body, the woman's words were made audible over the wireless set. And the joke was on the men with their loop aerials. The mysterious speaker was but a law-abiding citizen; the woman was his fiancée and the mysterious numerals' names and words all referred to plans for the approaching wedding.

Never again would the operators be caught napping if another one-sided conversation came to their ears. They expressed their appreciation of the joke in the form of a wedding gift to the couple who so unconsciously had caused them so many sleepless nights. It was a silver goat bearing the inscription "You got ours." It was accompanied by a card on which was written: *"With the best wishes of the Secret Service of the Air."*

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Westinghouse

THE CHURCH SERVICE COMES TO GRANDMA

No longer need the shut-in be deprived of the privilege of listening to the country's best preachers. The radio is beginning to bring his voice even into the remote rural districts.

idea came to one of the members of the board of trustees.

"Why can't we hook up to this new thing called the radio telephone and get our service that way?"

No one could answer him because no one knew anything about it; and moreover there was no one they could go to for information, as the experiment had never been tried. They were breaking new land; virgin soil. How could it be done? What about wires? Would people go to church when there wasn't a minister in sight? The idea was top-heavy with questions.

The experiment was tried. An amplifying horn was placed in the pulpit and a loop aerial set up beside it; and then with fears and doubts they awaited Sunday morning. Would the people come? Would they demand a living personality? That was what they had been told. Sunday morning arrived; the people came; the instrument was tuned up—and the service was as clear and distinct as it was to the people in the "parent" church several miles away. Even the coughing of the members of the congregation could be heard! The service moved along until the collection was announced—and two sprightly ushers bounced out into the middle of the aisle. There was nothing lacking except a preacher and a choir.

The service was a success, but the board was afraid that for the first Sunday the church had drawn merely a curiosity audience. But the next Sunday there were just as many people as on the first occasion. The congregation began to grow and soon there were as many people in the audience as when there had

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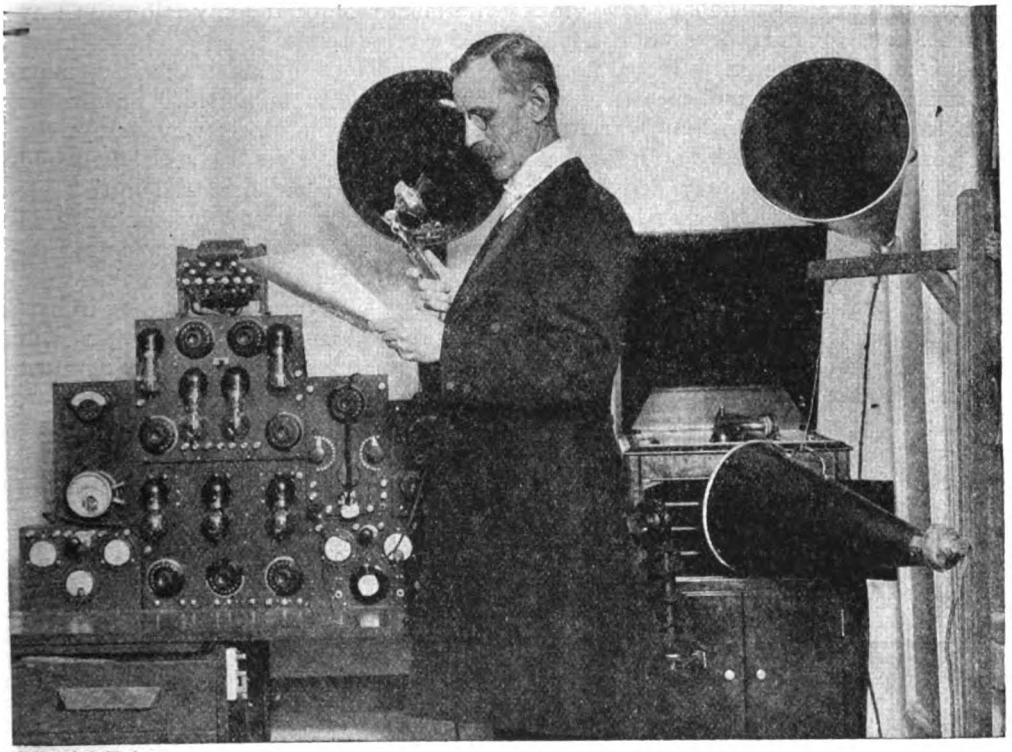

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HOW LARGE IS HIS SUNDAY AUDIENCE?

The average church attendance is small; even in the large city churches it is considerably smaller than the average theater audience. But the preacher who talks by radio may reach tens of thousands.

been a pastor in the pulpit. In fact, in some respects the service was better, as the sending church was larger, had a better preacher and a better choir. The "pastorless" church was getting a higher class service than it would if it had to depend on itself.

The practice was taken up by other churches until now it is known in several states.

January 2nd, 1921, marks, probably, one of the biggest changes that has ever come into the church. It means the centralizing of the church; the doing away with so many conflicting and needless creeds; so much useless competition and so many petty jealousies which for so long have been a millstone around the neck of the church. Church services will be shortened; much of the verbal underbrush will be cleared out, for sermons that go over the radio will have to say something. They will have to be more than an impressive collection of words. They will have to carry a message and get it over simply and directly.

The radio will mark the disappearance of numbers of small struggling churches and the centralizing of services in a few of the larger ones. Instead of there being thousands of small churches there will be a few large, flourishing ones with exceptional, outstanding pastors. Two or three will suffice for a city the size of Detroit. All those who must stick to one denomination will tune in with the belief that appeals to them most strongly, but ultimately the preacher with the message will be the one that will attract the people. In fact—and be it understood that this is only in the realm of speculation—one exceptional and outstanding

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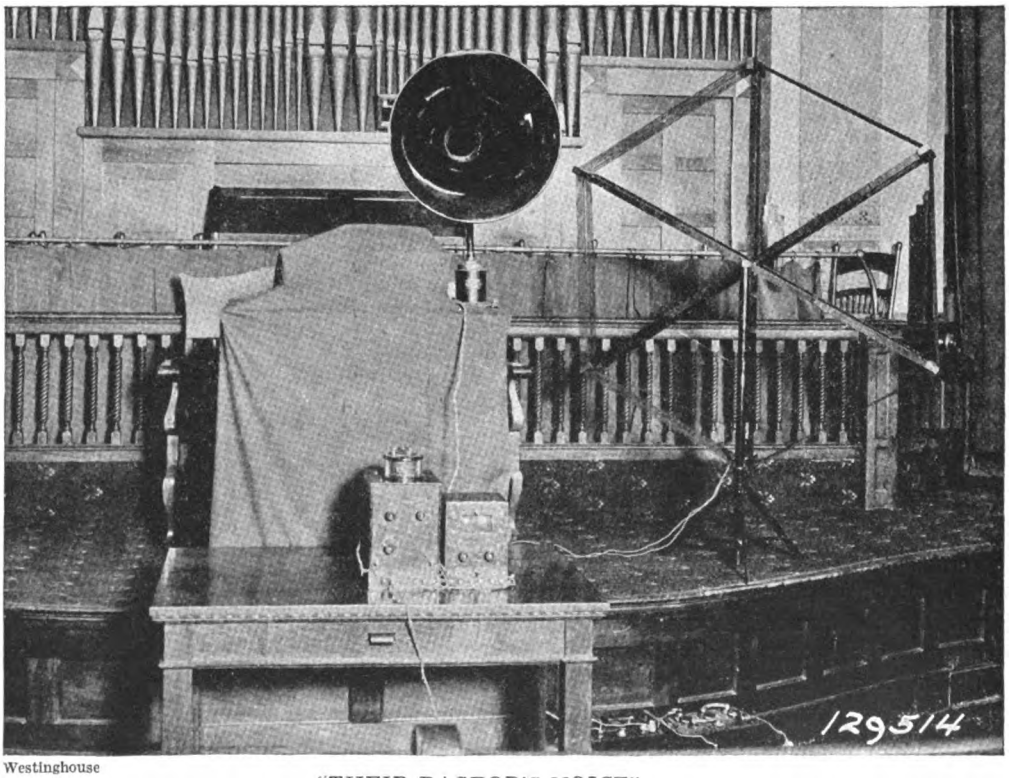
preacher may each Sunday have the United States for his congregation. Billy Sunday at his home in Winona Lake, Indiana, may have an audience that extends from New York to San Francisco, and from Canada to Mexico and, for that matter, lap over. He may deliver his sermon from his own home, but it is more probable that he will go to some church where there is a choir and the thrill of a crowd. And no doubt somewhere in the offing will be Homer Rodeheaver with his trombone.

A new audience will be added to the church: cripples, shut-ins, and mothers too tired to go. Cripples who have not been to church in years will have the word of God brought to them. Trained choirs will sing, great pipe organs play and Farmer Jones sitting in his rocking-chair in Boone Stop, Missouri, will hear. The tabernacle of the city is on the way to the cross-roads.

The audience, in the era now opening upon us, will be unlimited. Passengers on liners plowing their way across the ocean will gather in the social hall and listen to sermons delivered on land; people speeding across the continent in trains will participate in the services; passengers in airplanes will listen above the chugging of the machinery, sailors in battleships, and men in submarines will pause for the sermon; men who must work in coal mines on Sundays will hear, and lonely sheep herders will erect their aerials and bow their heads in worship. People in the air, in the water and in the lonely places of the earth will stop to listen. Such an audience is staggering to the imagination, but it is coming.

And soon.



Westinghouse

"THEIR PASTOR'S VOICE"——

—but the pastor himself was miles away, preaching by radio not only to his own flock but to other congregations as well. This loud speaker and loop aerial were installed in the Herron Avenue Presbyterian Church in Pittsburgh.

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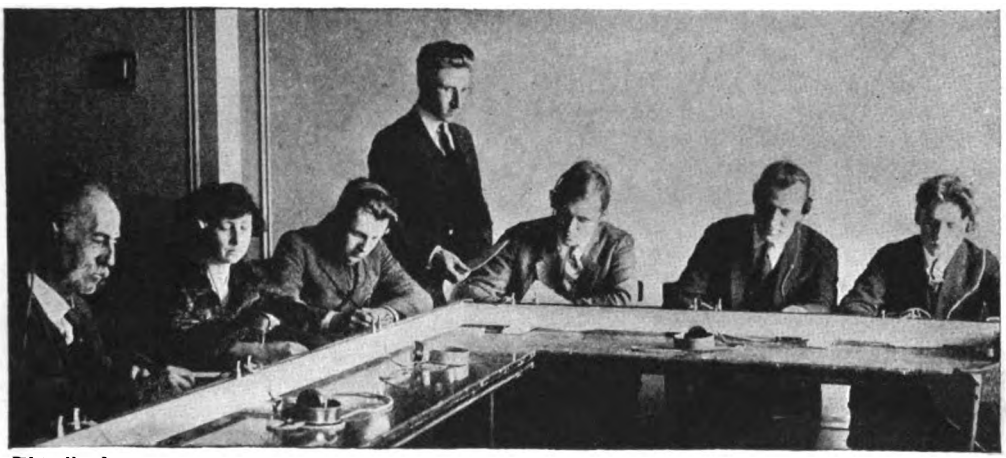

International

CANDIDATES BEING EXAMINED FOR AMATEUR RADIO LICENSES

Licenses are required for transmitting only. To qualify, the candidate must demonstrate his or her capacity to receive and send ten words a minute in the code.

How *to* Learn *the* Code

Sooner or Later Every Owner of a Receiving Set Wants to Enter the Inner Circle of the Ether by Reading the Morse Signals—and the Genuine Radio Fan Learns Them. This Article Is Written by One Who Did—

PAUL McGINNIS

THE student of radio code grows impatient with his perfectly good mind when he tells it again and again that "da de da da" is the letter "Y", and he wonders how any mind can be so stupid. He is too harsh with himself.

Even when the student has progressed more or less steadily, and when he is about fast enough to secure a first grade license, his mind often seems to make no progress for weeks and even months at a time. Some students quit in disgust at such a time, little knowing that success waits just around the corner and that their minds have been working faithfully all the while.

Success does not come by speeding up the progress of copying down the letters as they are sent, but rather by forming new habits of hearing entire words and even phrases without paying specific attention to the individual letters which form them.

The radio code is a foreign language. No one could speak a language fluently if he stopped to spell each word to himself, no matter how fast his mind might work. He must think in phrases, which he has heard so often that his mind forms them almost automatically.

The operator who copies forty words a minute usually strains less than the beginner who copies ten. His mind does not work faster than the mind of the beginner; it merely works with fewer acts.

As the experienced operator sits at his typewriter and copies an important message coming, perhaps, from a statesman or a king, he changes the paper in his machine. He even tells a joke to another operator beside him, and maintains his normal rate of speed although he may have been working eight hours. He is at ease, and has none of the worry of the beginner who strains to catch every

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letter separately as it comes to him.

But he was once a beginner himself, and he strained his mind before he learned a better way. He first learned the dots and dashes which go to make up letters, and he learned them slowly, thinking them over as he went to sleep perhaps, and wondering when he would ever distinguish between Q and Y.

Some schools prefer that the students learn the letters by sound only and ask them never to look at charts which show the dots and dashes used for each letter. They may be in the right, for the sense of hearing is the one which is most concerned, and the sense which must be developed.

Not all minds are alike, however, in their processes of learning. The mind with the strongest visual memory no doubt makes better progress at the start by looking at a chart; such a mind must listen to the buzzer for the auditory sensation of the letter, and then refer to its visual memory to identify the letter by its arrangement of dots and dashes.

The visual process is a roundabout way, of course, and must soon be discarded for the simpler system of auditory memory. The auditory system of teaching, without the chart, is quite likely the best, although there is no way to prove it.

The beginner with a keen visual memory may often startle his friends with his rapid start, but learning the code is a true art which has no short cut, and sooner or later he slackens his pace, and his friends overtake him.

An ordinary mind can remember six figures when they are spoken, and can usually repeat them, both forward and backward. Some minds, of the keen visual type, can retain as many as ten or more figures "in the mind's eye," and repeat them at leisure. If such a mind exists in a class, and the instructor sends ten letters at a time, the student with the unusual mind can retain the letters and set them down at leisure usually to the astonishment of his classmates, most of whom have been unable to receive more than two or three of the letters.

Such a student will stand well in his class always, but if he is to become a fast operator, he must discard the visual processes and learn to write letters, words, and then phrases as he hears them.

Learning the code is much like solving a puzzle. Little Willie in the fourth grade humiliates his venerable old grandfather by learning the trick of it before grandfather, with all his great store of knowledge, has obtained a good start in finding the solution.

The code, in its democratic way, offers the same lengthy task to the old as well as the young and to the quick as well as the slow.

As the long and short buzzes come to the ear in a complex maze, the mind at first strains and can make nothing out of the confusion. It sounds like "oodle oodle de oodle" to the novice. The student in the classroom is almost as much at sea, even though the signals are much slower.

He is unable to distinguish between the letters at all until suddenly some feature catches his ear and helps to fix the signal in his mind. The single dash for T and the single dot for E are distinguished first as a rule, and other letters fix themselves in the mind much more slowly.

Perhaps the beginner discovers that the signal for Q is like the warning whistle of a train as it approaches a crossing; two long notes, a short one and then another long one. Thus, the similarity helps him to recognize Q when it comes to him slowly, but he must forget the similarity later if he is to become a fast operator. He will not have time to think "train whistle" before his pencil writes Q. He must make his actions more simple and automatically write Q, just as a German says *"rot"* or a Frenchman says *"rouge"* or a Spaniard says *"roto"* when he speaks of the color red.

He must not be discouraged if his pencil stands still when the buzzes of the

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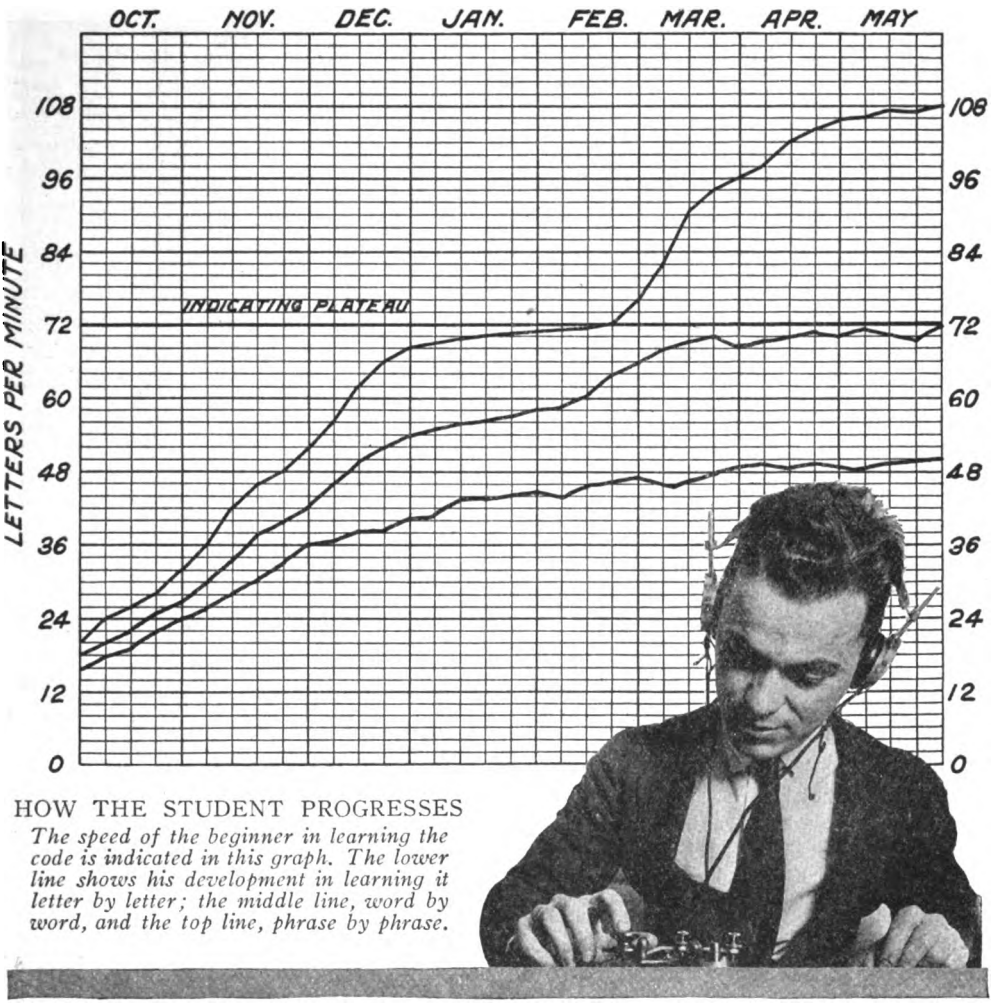

HOW THE STUDENT PROGRESSES

The speed of the beginner in learning the code is indicated in this graph. The lower line shows his development in learning it letter by letter; the middle line, word by word, and the top line, phrase by phrase.

letter Q come to him, even though he knows perfectly well, a second later, that the letter was Q. A mother must point many times to a hat or coat and say "red" before her baby finally understands, and the college instructor finds the same difficulty in teaching a foreign language.

If the mind is kept continually open and sensitive to the signals it will after a time eliminate errors and discover short cuts. The beginner who is discouraged needs only to recall his efforts in first learning to put on his collar and tie his necktie. His fingers were slow, and he invented many ways of pushing collar buttons through button holes until he found himself one day doing the trick seemingly without thinking anything about it.

During the process of learning the code, there are dull days, weeks and even months, during which periods the student seems to make no progress at all. Such apparently inactive periods may be caused by discouragement or inattention; perhaps the copying of messages seems too easy. At any rate, there is at least one period in the code student's progress as shown in the accompanying chart, when his mind seems to be at a standstill.

The curves shown on the chart represent the progress of a group of students who were learning telegraphy. The curves show in a general way how a

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student can expect his mind to act. In the curve marked "receiving" an inactive period or "mental plateau" is shown to occur during the fourth and fifth months of the student's efforts.

The accepted explanation of the plateau is thus set forth by Prof. R. S. Woodworth, of the Department of Psychology at Columbia University:

"The plateau is the figurative indication of a natural slowing down in the progress of the student during a period of study, and is followed ordinarily by signs of renewed impetus caused by the adoption of improved methods."

To progress from the plateau stage it is necessary not to increase the speed of the acts which the mind has already learned to perform, but to learn new habits of hearing words and even phrases in their entirety. Such new habits can come only from continued practice; while the mind seems to have gone stale, it is really getting a fresh start in a new direction as is shown decidedly by the abrupt upward trend of the curve after five or six months.

The plateau may come at the end of three, four or five months, and it may last much longer than a month or two, depending upon the individual's alertness. It is a bugbear to the student who does not understand it, but he should not be discouraged, for it comes to all beginners, regardless of their ability.

The beginner should learn, by all means, to "copy behind," that is, to write down the words several seconds after they are sent. This is the only safe method, for if he tries to keep up with the ticks he is apt to anticipate them and, hearing the first half of a familiar word, write the whole word and thus make mistakes.

Experts can copy from six to ten and even twelve words behind, depending upon their power to remember the words. They find it good practice to keep behind, for the meaning of the sentence may help them to make out a word of which they were not quite certain.

To shift from copying letters to copying words often stumps the student. At first he is sure to miss many of the words and his copy is hopelessly incomplete. He thinks it is better to copy letters, leaving out of uncertain ones and trusting that he will catch enough letters to make out most of the words. He hates to miss an entire word. It seems stupid to him.

He should realize that he is starting all over again, in a sense, and that he is learning *words* and *phrases* instead of *letters*. He must think of letters only when they come to him detached or in coded messages. He will find that such "mixed" messages will be easy enough; he will copy the words readily and will have plenty of time to think of the detached letters and figures.

The word-habit will cause many mistakes at first, but after a time it will not only be simpler but superior in accuracy.

Copying with a typewriter is much faster than with a pencil after the operator has learned the keys. A single movement in pressing a typewriter key takes the place of a series of movements in making a letter with a pencil.

To send with a telegraph key is much easier than to receive at first; that is because the fingers always know just what to do. As the chart indicates, a speed of some twenty words a minute is attained with almost steady progress.

The plateau in learning to send is not marked, although the hand can actually be made to think in words instead of letters and can acquire trains of action. A slight plateau is shown in the curve after about two months of practice. It is at this time that the hand is learning to send words instead of letters, and is busy learning the trains of action which form common words.

Perhaps the most obvious train of action in every day life is demonstrated unconsciously when we dress and undress. Almost everyone at some time has started to take off his shoes only and has suddenly awakened from his absent-mindedness to find that he has removed his

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Form 772 a.

DEPARTMENT OF COMMERCE
BUREAU OF NAVIGATION
RADIO SERVICE

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION
LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION	QUESTION	ANSWER OR NOTICE
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?.....	This is.....
QRB	What is your distance?.....	My distance is.....
QRC	What is your true bearing?.....	My true bearing is.....degrees.
QRD	Where are you bound for?.....	I am bound for.....
QRF	Where are you bound from?.....	I am bound from.....
QRG	What line do you belong to?.....	I belong to the.....Line.
QRH	What is your wave length in meters?.....	My wave length is.....meters.
QRJ	How many words have you to send?.....	I have.....words to send.
QRK	How do you receive me?.....	I am receiving well.
QRL	Are you receiving badly? Shall I send 20? . . — . for adjustment?	I am receiving badly. Please send 20. . . — . for adjustment.
QRM	Are you being interfered with?.....	I am being interfered with.
QRN	Are the atmospherics strong?.....	Atmospherics are very strong.
QRO	Shall I increase power?.....	Increase power.
QRP	Shall I decrease power?.....	Decrease power.
QRQ	Shall I send faster?.....	Send faster.
QRS	Shall I send slower?.....	Send slower.
QRT	Shall I stop sending?.....	Stop sending.
QRU	Have you anything for me?.....	I have nothing for you.
QRV	Are you ready?.....	I am ready. All right now.
QRW	Are you busy?.....	I am busy (or: I am busy with.....). Please do not interfere.
QRX	Shall I stand by?.....	Stand by. I will call you when required.
QRY	When will be my turn?.....	Your turn will be No.....
QRZ	Are my signals weak?.....	Your signals are weak.
QSA	Are my signals strong?.....	Your signals are strong.
QSB	Is my tone bad?.....	The tone is bad.
	Is my spark bad?.....	The spark is bad.
QSC	Is my spacing bad?.....	Your spacing is bad.
QSD	What is your time?.....	My time is.....
QSF	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG	.....	Transmission will be in series of 5 messages.
QSH	.....	Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for.....?	Collect.....
QSK	Is the last radiogram canceled	The last radiogram is canceled.
QSL	Did you get my receipt?.....	Please acknowledge.
QSM	What is your true course?.....	My true course is.....degrees.
QSN	Are you in communication with land?.....	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with.....)?	I am in communication with..... (through.....).
QSP	Shall I inform.....that you are calling him?	Inform.....that I am calling him.
QSQ	Is.....calling me?.....	You are being called by.....
QSR	Will you forward the radiogram?.....	I will forward the radiogram.
QST	Have you received the general call?.....	General call to all stations.
QSU	Please call me when you have finished (or: at.....o'clock)?	Will call when I have finished.
*QSV	Is public correspondence being handled?....	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?.....	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?.....	Decrease your spark frequency.
QSY	Shall I send on a wave length of..... meters?	Let us change to the wave length of..... meters.
QSZ	.....	Send each word twice. I have difficulty in receiving you.
QTA	.....	Repeat the last radiogram.
QTE	What is my true bearing?.....	Your true bearing is ..... degrees from .....
QTF	What is my position?.....	Your position is .... latitude .... longitude.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

THE NUCLEUS OF A UNIVERSAL LANGUAGE

These abbreviations are observed internationally; they constitute what is, in effect, the beginning of a world tongue. Every amateur who applies for a license to transmit must pass an examination on this list.

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Form 773 a.

DEPARTMENT OF COMMERCE
BUREAU OF NAVIGATION
RADIO SERVICE

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS
TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A . —	Period . . . . .
B — . . .	Semicolon — . — . — .
C — . — .	Comma . — . — . —
D — . .	Colon — — — . . .
E .	Interrogation . . — — . .
F . . — .	Exclamation point — — . . — —
G — — .	Apostrophe . — — — — .
H	Hyphen — . . . —
I . .	Bar indicating fraction — . . — .
J . — — —	Parenthesis — . — — . —
K — . —	Inverted commas . — . . — .
L . — . .	Underline . . — — . —
M — —	Double dash — . . . —
N — .	Distress Call . . . — — — . . .
O — — —	Attention call to precede every transmission — . — . —
P . — — .	General inquiry call — . — . — — . —
Q — — . —	From (de) — . . .
R . — .	Invitation to transmit (go ahead) — . —
S . . .	Warning—high power — — . . — —
T —	Question (please repeat after.....)— interrupting long messages . . — — . .
U . . —	Wait . — . . .
V . . . —	Break (Bk.) (double dash) — . . . —
W . — —	Understand . . . — .
X — . . —	Error . . . . .
Y — . — —	Received (O. K.) . — .
Z — — . .	Position report (to precede all position messages) — . — .
Ä (German) . — . —	End of each message (cross) . — . — .
Á or Å (Spanish-Scandinavian) . — — . —	Transmission finished (end of work) (conclusion of correspondence) . . . — . —
CH (German-Spanish) — — — —	
É (French) . . — . .	
Ñ (Spanish) — — . — —	
Ö (German) — — — .	
Ü (German) . . — —	
1 . — — — —	
2 . . — — —	
3 . . . — —	
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5	
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9 — — — — .	
0 — — — — —	

THE KEY TO THE INNER CIRCLE OF THE ETHER

Fifteen minutes of study a day for a period of a month will give the average man (or woman) sufficient knowledge of the code to enable him to read most of the amateur signals. A buzzer practice set may be obtained for about two dollars.

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hose and perhaps other garments as well.

The victim of such absent-mindedness has formed a train of action in undressing. He has followed this train in the same way for years, and when he once starts his mind on the train by removing his shoes, he continues without conscious effort.

In the same way the muscles of the hand learn to send common words in code. The operator has only to think the word; he does not think the letters. And his hand ticks it out. Common words such as "the", "and", "but", and "in" are learned almost at the outset. Endings of words such as "ing" and "ion" become automatic; after long training the hand acquires an extensive vocabulary of words which it sends in trains.

After three or four months the hand has approximately reached its muscular limit in the speed of sending letters and its progress from that time on comes in sending word trains which are not slowed down by the brain that thinks of each letter.

After a certain point in training is reached, sending is learned much more slowly than receiving because the mind can be trained to work much faster than the fingers; if a typewriter is used the operator can receive much faster than he can send. He can eventually find time to correct the sender's mistakes as he writes the message down.

Most beginners have heard of the "glass arm", but most of them do not take proper care to prevent it.

If the key is operated with the fingers or with the muscles of the hand, the continual strain will sooner or later cause temporary paralysis when the operator attempts to send with a key; this condition is known in the trade as the "glass arm." The operator may be able to write and use his hand in any other way, but when he attempts to send a message with a key, his hand and arm become rigid and will not obey him.

Almost any good operator can show the beginner how to place his fingers lightly on the key and make the movements with his wrist in the proper manner.

Progress at first will be much slower than would be the case if the student used his fingers to form the dots and dashes, but in the end the wrist movement is much the speedier. A tired hand or wrist is a danger signal and shows that the method of sending is wrong. A perfect wrist movement will enable an operator to send for hours, causing him little more fatigue than would come from writing a letter or other mild exercise of the hand and forearm.

RADIO PUTS SPEECH INTO MOTION PICTURE FILM

DURING the recent brief visit to this country of Dr. Lee de Forest, arrangements were made with him to write for this magazine an article that will describe his latest experimental work with one phase of the de Forest audion tube activity about which but little has been written —its capacity to produce synthetic music from light! This development paves the way for that long-sought phenomenon—the motion picture film that talks.

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International

SIR ARTHUR CONAN DOYLE SAYS:

"I EXPECT *in the next three or four years some definite messages will be received to prove the contentions of the spiritualists. I believe they will come through radio. I think it is along this line that we will get our evidence. They have transmitters in the line of ether and all we have to have is the receiver. We will have the direct communication that Edison hoped for.*"

Are *the* Dead Trying *to* Reach Us by Radio?

The Second of a Series of Articles that Describes the Experiments of Psychic Investigators for Establishing Communication with a Possible Spiritual World through the Medium of Delicate Electrical Instruments

By HEREWARD CARRINGTON, Ph. D.

In the preceding article, published in the June number, Dr. Carrington pointed out the scientific possibility of some form of instrumental communication with a spiritual world, if such a world exists; granting the reality of such a world, communication with it through the medium of highly sensitive radio apparatus might conceivably be established.

The author pointed out that thought appears to be dynamic in its action, and sets up certain definite etheric radiations, which can apparently be detected. Such being the case, it would appear to be a short step to the construction of a possible "detector" delicate enough to register these ether impulses. Dr. Carrington believes we are on the eve of such a discovery, and it is upon this problem that he is now experimenting in the Psychical Laboratory in New York.

—EDITOR

THE all-pervading ether which science has stated surrounds us, penetrates every cell and molecule of our bodies and of our brains. Life must, accordingly, exist in this medium, insofar as we ourselves exist in it; insofar, indeed, as our minds and consciousness also exist in it. Mind is, therefore, in "contact" with it.

But what is ether? No one knows. Haeckel was inclined to believe that it is such a fine gas that a sphere of it the size of our earth would weigh but 250 pounds. Lodge, on the other hand, contends that it is more solid and dense than platinum and

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gold. Dr. Steinmetz, in this issue of POPULAR RADIO, advances still another conception of it. Lord Kelvin said that no man could believe in the ether who did not also believe that it presented opposite and contrary properties. We can hardly dogmatize, then, as to the nature of this ether.

Is the ether atomic in structure? If so, what exists in its intra-atomic spaces? Another ether? I have already stated that occult science contends that there may be four ethers, one above or within the other. Certainly this theory may be accepted as a possibility. Various solid bodies can occupy the same space, if they are of differing densities. We can, for example fill a glass "full" of marbles; we can then fill in the spaces between the marbles with coarse shot; we can fill the spaces between these coarse shot with fine shot, and the spaces between the fine shot with water. It is conceivable at least, that this process may go on indefinitely; certainly we do not know where it may end. And just as air and ether carry different rates of vibration, as expressed in sound and light, so it seems reasonable to suppose that varying ethers, if they exist at all, may convey differing rates of vibratory activity, which are not detectible in another medium.

If this be true, the difficulty which has been experienced in detecting any form of brain waves or telepathic impulses may be explained. These impulses might exist, but be conveyed in some "mentiferous ether," as already suggested. When we discover that, then we shall immediately be enabled to register the waves which are operative in telepathy.

Already, Dr. E. E. Free, in a recent interview, has asserted his belief in the possibility of detecting such impulses electrically, by means of suitable instruments. He says:

> "There is no physical improbability that in the nerves of, say, the human brain exists some arrangement of tissues or of chemical molecules, competent to act as a wireless detector for such wireless impulses as may be sent out, as the result of nerve impulses originating elsewhere—as within other brains, for instance.
>
> "What would this be but telepathy?
>
> "But one must not become too speculative. Our only facts at present are that nerve energy is electrical, and that all electrical disturbances start wireless waves.
>
> "From these as an abutment we have built into the unknown what might be called a cantilever bridge of speculation . . . It has two essential members in its structure. One, the hypothesis that the wireless waves sent out are really sufficiently distinct and powerful to be detected by possible apparatus; and second, that such a receiving apparatus may exist within the human brain. . . ."

Both of these speculations surely seem rational.

It is not necessary to presume in such cases, that the thought itself is transmitted, any more than it is in wireless telephony. Only vibrations would be sent and received, and these vibrations would be re-translated upon arrival at their destination. Just as the chemical action in a battery remains in the battery, but is represented outside by its "dynamic correlate," known as the current, so in the case of the brain the dynamic correlate of thought, whatever that may be, remains in the brain. But its vibratory expression is transmitted outward into space, as a form of undulatory motion or ether waves.

To sum up my hypothesis, I may state:

In order to obtain a specific action we must employ a specific instrument—a telephone for a telephone, a brain for a brain.

Every living thing is a dynamic focus.

A dynamic focus tends ever to propagate the motion which is proper to it.

Propagated motion becomes transformed according to the medium it traverses; a force may be transmitted or transformed.

In an identical medium there is only transmission; in a different medium there is transformation.

If thought is dynamic in its expression, it may be transmitted and transformed. Then it may be re-transformed in another organism, which supplies the necessary conditions. Thought may be restored.

All this may be conceded so long as we have physical brains. But what of

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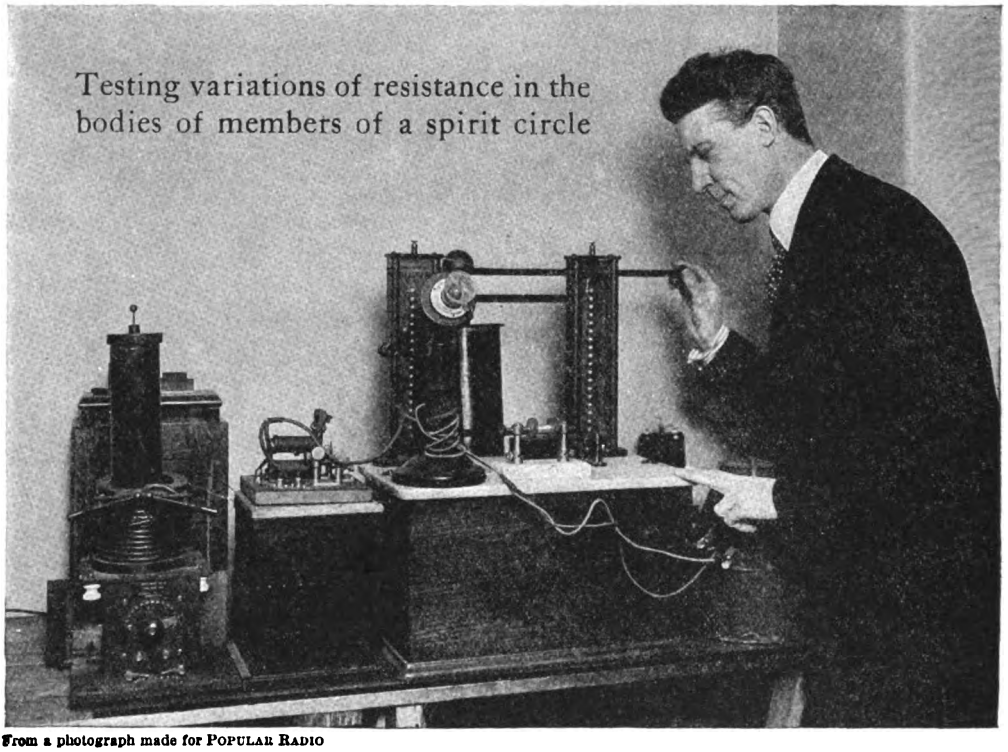

Testing variations of resistance in the bodies of members of a spirit circle

From a photograph made for POPULAR RADIO

beings who no longer have such organs? What are we to say as to the inhabitants of some spiritual world? If such exist at all, they are certainly devoid of brains as we know them. How then, would any form of instrumental communication with such spiritual beings be possible or even conceivable?

First of all, it is now certain that the body itself does not feel, does not sense. The eyes do not see, the ears do not hear. It is the inner being within which sees, hears and senses. Physiology proves this. It has been contended that in addition to our physical bodies we also possess an etheric double, or "astral body," resembling the physical body in all its detail, and that it is this body which is the seat of the emotions, the feelings and the sensibilities. There is a great deal of actual evidence of the existence of some such invisible body. If certain French investigations are to be credited, it has been seen, felt and photographed; it has moved mechanical instruments; it has caused certain chemical screens (calcium sulphide) to glow with added brilliance when approached by it. Calculations have been made as to its density, structure and weight. According to these researches, we have a fairly good general idea as to its nature.

This invisible, inner body, then, may possibly be the vehicle of thought. It may possess centers whose normal office is to send and receive telepathic messages. One etheric center may thus act upon another etheric center directly, and only indirectly upon the physical brain cells. The action would thus be dynamic, yet psychical; physical in a sense, yet not physical as we conceive it. There is here a sort of physical communication of a spiritual thing. Its activity may take place in some higher ether or be some mode of activity in the ether which we cannot yet register. But that is no proof that such registration is impossible; on the contrary, it is my belief that it is possible, and will one day be registered. It seems, therefore, that

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it is merely a problem of developing sufficiently-attuned apparatus of the right kind, before we will detect and register these subtle mental vibrations. And these vibrations need not necessarily emanate from a physical brain, as we have seen. We may conceivably receive telepathic impulses from the dead!

The question which presents itself for practical solution, therefore, resolves itself down to this:

What sort of apparatus must we employ; what kind of detectors must we use, in order to register those etheric undulations which may be sent out from discarnate minds? And, having once detected and measured these wavelengths, what device could we construct which would enable us to send out the same sort of subtle etheric waves which, we may assume, would be somehow registered at the other end of the line? For if a definite wavelength can be transmitted, it is natural to suppose, *a priori,* that the same wavelength could be received by some inner mechanism.

The reader must not expect me to furnish him with a detailed list of blue prints, and say, "Construct a piece of apparatus in *this* manner, and you will receive messages and communications at once from the spirit world!" Were this possible, the problem would already have been solved; there would be no doubt concerning it at all. This cannot yet be done. But much can be done by clearing away doubts and misconceptions, by indicating the road which we must travel, and suggesting the kind of apparatus which must be employed, in order to obtain any possible results. Experiments of this character are now being made in the American Psychical Institute and Laboratory, and readers of this magazine may care to undertake experiments of a similar character. If so, I should be glad to hear from them and to receive reports of their investigations.

One of the first problems that we must solve, is to discover the nature and length of "brain waves" by experiments in telepathy. The two subjects may be placed in a high-tension electric field, or in a space across which carrier waves of known length and frequency are passing. These carrier waves, as already suggested, would doubtless reinforce and possibly render evident the etheric undulations that are operative in telepathy. If these could then be detected and calibrated, we should have made our first definite forward step toward an understanding of direct mental action, expressed through a certain machine—in this case the human body and brain.

Then we should devise a suitable detector, capable of registering these ether waves with accuracy and facility. Once the detector had been perfected, the next step would be the perfection of a sending apparatus, emitting the same form of wavelengths at the same frequency.

Experiments should also be tried in obtaining possible direct pressures and registrations by subtle forces. The mere exercise of an energy in itself would prove little; but if it manifested signs of intelligence, then we should have something of value and significance.

Doctors Matla and Zaalberg van Zelst, of The Hague, Holland, claim that they have already received direct communications in this manner, when no medium at all was present. Their apparatus was elaborate; the principle of it was as follows: The letters of the alphabet were painted on a flat disk, which slowly revolved. One letter at a time appeared in an opening that was cut in a card that covered this disk. Lower down, was the "key" of the instrument; it consisted of a flat plate, very delicately balanced; the slightest pressure on it would complete an electric circuit. When this key was pressed by some invisible being or force, at that moment the letter "M" (say) appeared in the opening above and this letter was automatically printed on a sort of ticker-tape.

In this way the messages were spelled out; long messages, it is claimed, were recorded and were published in a book entitled "The Mystery of Death," pub-

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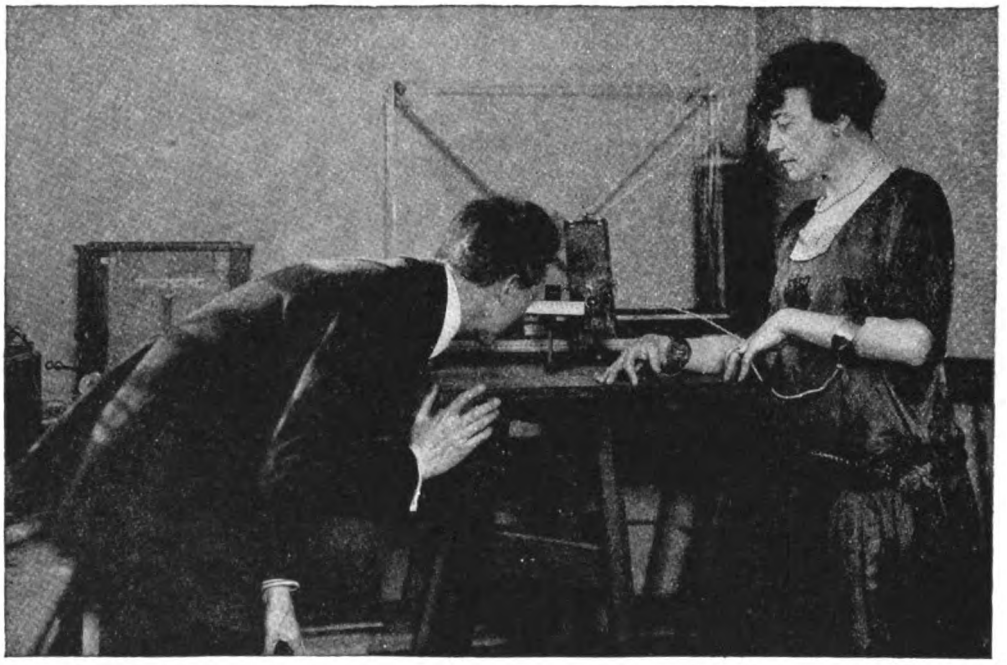

From a photograph made for Popular Radio

MEASURING THE PSYCHO-GALVANIC REFLEXES OF A MEDIUM

Our body is in effect an electric battery; its power varies with our mental activity and our emotions. By means of a galvanometer the current impulses may be measured to 1-millionth of an ampere. Dr. Carrington believes that thought impulses from a spiritual world may some day be recorded on some such highly sensitive instrument.

lished first in Dutch and later in French.

It is possible, however, that messages of this character cannot be received unless some other factor be present, and that factor is life. Vital force, vital energy, life—whatever that may be—seems to be a necessary factor in nearly all these manifestations, and it is possible that we cannot obtain them without its presence, directly or indirectly. This life force seems to be utilized, in some mysterious way, and rapidly expended in the production of many of these phenomena; but the close relationship between life and electricity should not be lost sight of in this connection. Is there not a bridge between the two—a bridge which can be discovered, uniting and connecting them? And across this bridge may not action and interaction take place, of a nature hitherto unsuspected? It seems rational to suppose so. We stand here upon the border line of life and matter, in that mysterious realm that connects soul and body, and it is here that discoveries of the greatest significance will assuredly be made in the near future.

We already have, in our Psychical Laboratory, instruments that detect the differences between various bodily radiations and devices which record the energy-changes of members of a circle. Radiations from the body, and especially from the finger-tips, appear to be proved. Yet if this be true, we have here cases of nerve-energy, or life-force, that exists outside the body, in space, that acts and reacts upon other forces and energies. If this "externalization" of life force be a fact, it opens up the possibility of conducting and even collecting it, and applying it like any other energy. If it could be "caught," as it were, we should then have this vital intermediary between the material and spiritual worlds, and be enabled to utilize it for communication.

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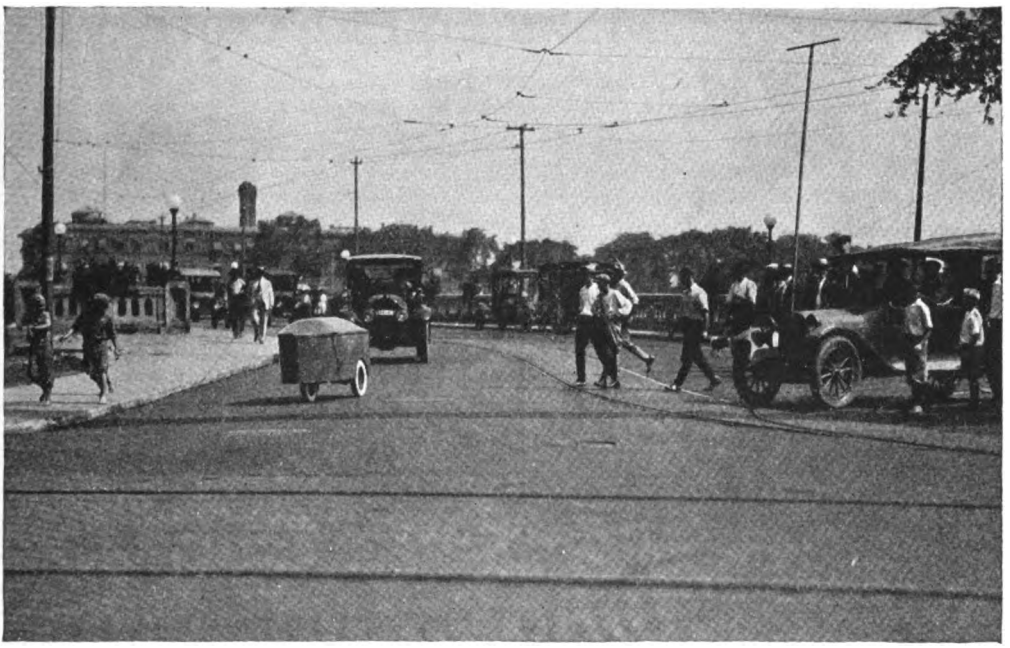
All sorts of fascinating possibilities come to the mind. If life, leaving the body at death, could be registered in some manner, might not experiments be conducted with this in view? We know that there is all the difference in the world between a living and a dead man; yet no physical change may be detectable. Something has, nevertheless, left the living man and that something is his life. If life could be somehow registered or "caught," at the moment of death, we should have here immediate proof of its persistence after the destruction of the physical body. Whether or not this life force contained a mind, consciousness and personality of its own would be another question—a question capable of solution, however, by proper methods of careful, scientific, psychical investigation.

Thus it would appear that a possible method of communication with some spiritual world—granting that it exists—may some day be established by means of highly sensitive radio apparatus that may record impulses too delicate to register on machines that have so far been devised. Such an idea is not as fantastic as might appear at first thought. Without departing essentially from recognized scientific facts or accepted psychical phenomena, I have shown that some such method of communication might be established in the future, when our methods of research have been more fully perfected. When our young experimentalists, especially in radio, begin working in this direction we may hope for startling results.

¶ This article will shortly be followed by an article written by Harry Houdini, president of the Society of American Magicians, who will describe how the fakers among the spiritualists have been using radio for years in staging tricks at their seances.



A RADIO-CONTROLLED MOTOR CAR ON A CITY STREET

Among the more spectacular achievements with radio, few have a wider interest than the guidance of cars, boats or airplanes from a distance. How this is done will be told in "How Machines Are Controlled by Radio," by Dr. Henry Smith Williams—in the August POPULAR RADIO.

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From a photograph made for POPULAR RADIO

THIS HOME-MADE SET COSTS FROM $15.00 to $22.00 FOR MATERIALS

Fastening the secondary coil to the sliding support. This sliding coil makes it possible to tune out interference on this set.

How *to* Make and Operate a Two-Circuit Receiving Set

Further evidence of the purpose of the Government authorities to encourage radio amateurs is furnished by these specifications, which have been carefully worked out by the Bureau of Standards, and issued as a sequel to the specifications of the crystal receiving set which were published in the May issue of this magazine.

By WATSON DAVIS

UNCLE SAM is telling the radio fan how to make his own receiving equipment that will enable him to snatch his share of the music, lectures, code and other wireless activity in the ether. The Bureau of Standards, Department of Commerce, cooperating with the Bureau of Markets, Department of Agriculture, has compiled these simple instructions for the amateur.

At a total cost of from about $15 to about $22, depending upon the quality of the telephone receivers and the condenser purchased, he can make an efficient radio receiver right at home that can distinguish between messages from different transmitting stations sent on wavelengths nearly the same. The outfit will enable anyone to hear radio code messages or music and voice sent from medium-power transmitting stations within an area about the size of a large city, and from high-power stations within fifty miles, provided the waves used by the sending stations have wave frequencies between 500 and 1500 kilocycles a second—that is, wavelengths between 600 and 200 meters. This equipment will not receive undamped (continuous) waves.

This set is superior to a single-circuit outfit as it is more selective, that is, it can be tuned sharper. Those who have con-

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structed the Bureau of Standards single-circuit $11 radio receiver according to instructions published in the May issue of this magazine can utilize all the parts of that set in making the better outfit described here.

The instructions tell how to make all the parts of a receiving station except the antenna, lightning switch and necessary ground connections. How to make and erect an antenna and make necessary connections to the receiving set was explained in the previous article.

Parts of the Set

The two-circuit receiving set consists essentially of a coupler, a variable condenser, a crystal detector, and accessories.

The assembled receiving set is shown in Figure 1, and Figure 2 shows how to wire the set.

The coupler, shown in left half of Figure 1, is composed of a fixed section made up of the coil tube P, the upright J, the contact panel K, and the base B, and a movable section composed of coil tube S, the supporting contact panel M and the base L.

The Movable or Secondary Coil

The coil tube S, (Figure 1), is a piece of cardboard tubing 3⅝ inches in diameter and 4 inches long. A round cardboard table-salt box which can be obtained at a grocery store is about 3⅝ inches in diameter and can be used for this purpose. One of the cardboard ends or caps should be securely glued to the box. This tube is wound with No. 24 (or No. 26) double cotton covered copper wire.

To wind the wire punch two holes in the tube ⅜ inch from the open end, as shown at R, Figure 2. Weave the end of the wire through these holes so that it is firmly anchored and has one end extending about 10 inches inside the tube. Punch a hole F about ⅝ inch from the other end (which has the cardboard cover secured to it) in line with the holes punched at R. Draw the free end of the wire through the inside of the tube and thread it out through the hole at F. Now wind on 10 turns of wire and take off a 6-inch twisted tap made by twisting a 6-inch loop of wire together at such a place that it will be slightly staggered from the first connection. Hold the turns tight and punch a hole B directly underneath this tap. Insert the end of the tap in the hole and pull it through the inside of the tube so that the turns are held in place. The hole for this tap should be slightly staggered from the first two holes which were punched. Punch another hole L ⅝ inch from the other end of the tube and in line with the hole B. Thread the twisted tap out through this hole and pull it tight. Wind on 10 more turns and bring out another twisted tap, then 10 more turns and another tap; 15 turns and another tap; 15 more turns and another tap. Finally, wind on 20 more turns and bring out the free end of the wire in the same manner as the taps were brought out. The tube now has 80 turns of wire wound on it and there are 5 twisted taps and two single wires projecting through the row of holes at the closed end of the tube. The position of the wires inside the coil tube is shown by the dotted lines.

The Base and Support for Coil

The contact panel M, Figure 1, which supports the coil tube is a piece of dry wood or Bakelite 5½ inches high, 4 inches wide and ½ inch thick. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. Having located the hole for the switch-arm bolt, the switch arm should be placed in position and the knob rotated in such a manner that the end of the contact arm will describe an arc upon which the contact points are to be placed. The holes for the contacts should next be drilled, the spacing depending upon the kind of contacts which are to be used.

The movable base L is a square piece of dry wood 4 inches long, 4 inches wide and about ¾ inch thick. Care should be taken to have the edges of this block cut square with respect to the sides.

Now screw panel M to the movable base L, as shown in Figure 1. Care should be taken to have the edges of the blocks M and L evenly lined up so that the two edges of the block L, Figure 1, which slide along the inside edges of the strips H and I will be smooth continuous surfaces.

The Parts Needed and the Approximate Cost

You will have to buy these parts of the set, or find them around the house:

6 ounces No. 24 double cotton covered copper wire	$ .80
2 round cardboard boxes	
3 switch knobs and blades, complete	1.50
24 switch contacts and nuts	1.00
3 binding posts; set-screw type	.45
4 binding posts; any type	.60
1 crystal; tested	.25
3 wood screws; brass, ¾ inch long	.03
2 wood screws for fastening the panel to the base	.02
Wood for panels (from a packing box)	
2 pounds paraffine	.30
Lamp cord; 2 to 3 cents a foot	
Telephone Receivers	4.00 to 8.00
1 battery clip for crystal	.10
Miscellaneous Screws	.30
1 variable condenser; 0.0004 to 0.0005 microfarads (400 to 500 micromicrofarads)	3.00 to 6.00

The Fixed or Primary Coil

The cardboard tubing or coil tube P is 4⅛ inches in diameter by 4 inches long. About 2 ounces of No. 24 (or No. 26) double cotton-covered copper wire is used for winding the coil. Punch two holes in the tube about ½ inch from one end. Weave the wire through these holes in such a way that the end of the

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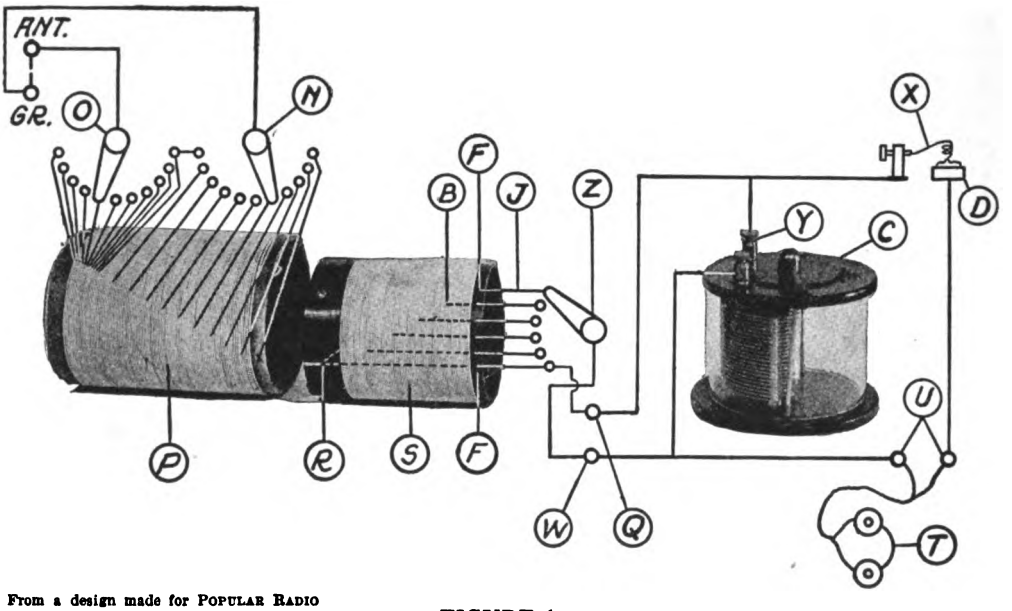

From a design made for POPULAR RADIO

FIGURE 1

What the electrical parts of the receiving set are, combined with a diagram that illustrates the system of wiring.

wire will be firmly anchored, leaving about 12 inches of the wire free for connecting. Start with the remainder of the wire to wind turns in a single layer about the tube, tight and close together. After one complete turn has been wound on the tube hold it tight and take off a tap. This tap is made by twisting a 6-inch loop of the wire together at such a place that it will be slightly staggered from the first connection. Proceed in this manner until 10 twisted taps have been taken off, one at every turn. After these first 10 turns have been wound on the tube, take off a 6-inch twisted tap for every succeeding 10 turns until 10 taps are taken off or 100 additional turns have been wound on the tube. After winding the last turn of wire anchor the end by weaving it through two holes punched in the tube as at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 21 taps is slightly staggered to the right from the one just above, so that the taps will not be bunched along one line on the cardboard tube. (See Figure 2.) It might be advisable, after winding the tuning coil, to dip the tuner in hot paraffine. Glue a cardboard cover to the end of the tube where the single turn taps are taken off.

The Panel

Panel K should be made from a board 7½ inches long by 4½ inches wide and about ½ inch thick. The position of the contacts can best be determined by inserting the switch arms in their respective holes and turning the knobs so that the ends of the switch arms will describe arcs. The position of the several holes for the binding posts, switch arms and switch contacts may first be laid out and drilled. The "antenna" and "ground" binding posts may be ordinary 8/32 brass bolts about 1½ inches long with three nuts and two washers. The first nut binds the bolt to the panel, the second nut holds one of the short pieces of stiff wire, while the third nut holds the antenna or ground wire as the case may be. The switch arm with knob may be purchased in the assembled form or it may be constructed from a ⅜-inch slice cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers, together with a strip of thin brass. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. The switch contacts may be of the regular type furnished for this purpose or they may be 6/32 brass bolts with one nut and one washer each.

The fixed base B is a piece of dry wood 5½ inches wide, 19 inches long and between ¾ and ⅞ inch thick. The support J for the fixed coil tube is 5½ inches wide (the width of the base), 6 inches long and about ½ inch thick. This board should be screwed to one end of the base so that it is held securely in a vertical position. It will then project about 5 inches above the base B.

A strip of wood I, 11 inches long, 5/16 inch wide and about ¼ inch thick is now fastened to the base by cigar-box nails or small brads so that it is even with the rear edge, as shown in Figure 1. The upright panel M having been fastened to the movable base L, as previously explained, is placed in position as shown. The next step is to locate the strip H in such a position that the block L will slide easily back

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and forth the entire length of the fixed base B. Having found this position this strip is secured in the same manner as the strip I. It is, of course, understood that neither the movable coil tube S nor the switch contacts and binding posts have, up to the present time, been mounted on the upright panel M. The wooden parts for the loose-coupler are now finished and should be covered with paraffine.

It might be advisable after winding the coil tubes P and S to dip them in hot paraffine. This will help to exclude moisture. Have the paraffine-heated until it just begins to smoke so that when the coils are removed they will have only a very thin coating of paraffine.

The Variable Condenser

The variable air condenser C should have a maximum capacity of between 0.0004 and 0.0005 microfarads (400 to 500 micromicrofarads.) The type pictured in Figure 1 is inclosed in a round glass case, but the "unmounted" type may also be used. The variable condenser is mounted on the base B, Figure 1. After the holes for the detector binding post, and also the holes for the telephone binding posts U have been drilled, the board should be coated with paraffine.

The Crystal Detector

The galena crystal D may be mounted as pictured in Figures 1 and 2. The holder for the crystal is a metallic pinch-clip such as the ordinary battery test clip or paper clip. This clip should be bent into a convenient shape so that it may be fastened to the base.

The wire X which makes contact with the crystal is a piece of fine wire (about No. 30) which is wound into the form of a spring and attached to a heavy piece of copper wire (about No. 14). This heavy wire is bent twice at right angles, passes through the binding post, and has a wood knob or cork fixed to its end as shown. It is desirable to have the fine wire of springy material such as German silver, but copper wire may be used if necessary.

The importance of securing a tested galena crystal can not be emphasized too strongly, and it should be understood that good results can not be obtained by using an insensitive crystal.

Assembling the Coupler

The movable portion of the coupler should be assembled first. As shown in Figure 1, the fittings making up this part of the set are the movable base L, the coil tube support M and the coil tube S. Insert in M the 6 switch contacts (machine screws), the switch arm, and the binding posts, in the proper holes which have been drilled. Adjust the switch arm until it presses firmly on the contact points (bolt heads) and fasten the bare end of a No. 24 copper wire between the nuts on the end of the switch-arm bolt 2, Figure 2, which projects through the panel M. Wind this wire into the form of a spiral of two or three turns like a clock-spring, leaving a few inches of the wire for connection. Insert two small screws V, Figure 1, in the panel M so that the switch arms will not drop off the row of contact points when the knob is turned too far.

The coil tube S is now ready to be fastened in position on the panel M. Cut a 1-inch hole in the cardboard end of the coil tube and place it with the closed end next to the panel M in such a position that it will be just below the row of nuts and washers (switch contacts) and in the center of the panel M with respect to the sides. Fasten it to the panel with short wood screws. The switch-arm bolt with the spiral wire connected to it should project through the hole cut in the end of the coil tube. Thread the end of this wire through a hole punched near the end of the coil tube next to the panel and connect this wire to the back of the binding post, W, Figures 1 and 2. The wire F, Figure 2, is now connected to the back of the binding post Q. There now remain 5 twisted taps and 1 wire to be connected to the 6 switch contacts. The taps should be cut off about 1½ inches from the coil tube and the insulation removed from the pairs of wires thus formed. Each pair of wires should be twisted together, as shown at J, Figure 2. The connections are now made by clamping the 5 taps and also the end of the single wire between the nuts and washers on the contact bolts. The connections are clearly shown in the diagram.

We are now ready to assemble and wire the fixed portion of the coupler, composed of the Base B, coil support J, panel K and coil tube P.

Screw the panel to the base and to the support J and insert the binding posts, switch arms and bolts, and contact bolts in the proper holes. The switch arms should now be adjusted so that they make firm contact on the heads of the bolts. Now insert 4 small screws, E, Figure 1, in the front of the panel so that the switch arms will not drop off the row of contact points when the knobs are turned too far. Insert a wire between the nuts on the end of the lower switch-arm bolt N where it projects through the back of the panel K, Figure 1. Wind the wire into a spiral of 1 or 2 turns like a clock-spring and connect the end to the upper binding post which is marked "Antenna." These connections will be understood by referring to the upper left-hand corner of Figure 2.

In the same manner connect another wire from the upper switch-arm bolt to the lower binding post which is marked "Ground." See Figure 2. The connecting wires should be insulated except where a connection is needed and should not touch each other. Two short pieces of wire are now fastened to the binding posts in the front of the panel, as previously explained.

The coil tube P should now be laid on the base in about the same position as it is shown in Figure 1. The 19 twisted taps and also the 2 single wires from the ends of the winding are now to be connected to the back of the 22 contacts on the panel K. Scrape the cotton insulation from the loop ends of the nineteen twisted taps as well as from the ends of the two single wire taps coming from the first and last turns. Fasten the bare ends of these wires to the proper switch contacts. Be careful not to cut or break any of the looped taps. The connecting wires may be fastened to the switch contacts by binding them between the washer

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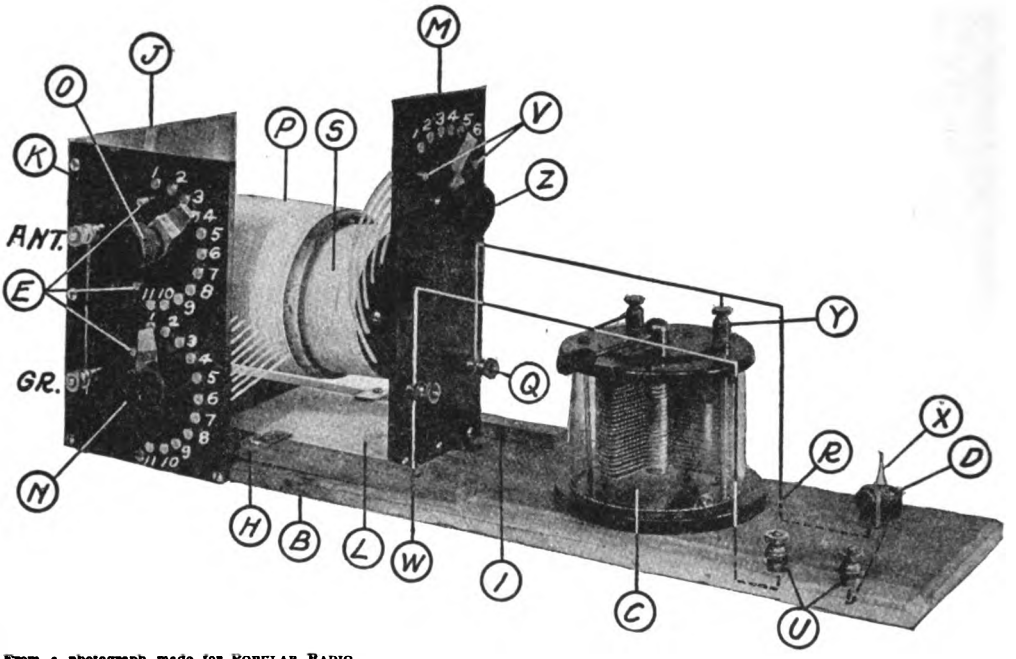

From a photograph made for POPULAR RADIO

FIGURE 2

How the parts of the set are assembled. This set will receive satisfactorily within an area of any large city, from medium-power stations and from high-power stations within 50 *miles.*

and the nut. The order of connecting the taps may be understood by referring to Figure 2.

Carefully raise the coil tube P against the support J to such a position that when the coil tube S of the movable section of the tuner is pushed in the coil tube P, the space between the two tubes will be equal all around. Mark this position of the coil tube P on J, and fasten it to J with short wood screws.

Wiring the Condenser and Crystal Detector

The mounting of the condenser C and the crystal detector D on the base R is clearly shown in Figure 1. A wire is run from the binding post Y on the variable condenser C, through a small hole in the base R, and is then connected to the under side of the detector binding post. Another wire is now run from the clip which holds the galena crystal, through a small hole in the base, and is then connected to the under side of the right-hand binding post U. The left-hand binding post U is next connected to the binding post on the variable condenser which has no wire attached to it, by running a wire under the base and up through a small hole. The wiring will be understood by referring to the right-hand portion of Figure 2. The wires may be the same size as were used for winding the coil tubes and should be insulated. Two pieces of wire should now be connected from the binding posts W and Q, Figures 1 and 2, to binding posts on the variable condenser. The telephone receivers T are now connected to the binding posts U and the receiving set is complete except for connecting to the antenna and ground.

Connect the antenna lead and ground wire to the binding post marked "Antenna" and "Ground."

Directions for Operating

Push the coil tube S (secondary) about half way into the coil tube P (primary) and set the switch Z on contact point 4. The primary switch O may be left in any position. The wire which rests on the crystal detector must be placed lightly at different points on the crystal until the transmitting station is heard when the set is adjusted as described below. During this operation the primary switch N should be set on contact point 5.

Having adjusted the crystal detector to a sensitive point, the next thing is to adjust the switches on the coil tube P (primary), the switch on the coil tube S (secondary) and also the variable condenser C, so that the apparatus will be in "resonance" with the transmitting station. Set the primary switch N on contact point 1, and while keeping it in this position move the other primary switch O over all of its contacts stopping a moment at each one. Care should be taken to see that the ends of the switch arms are not allowed to rest so that they will touch more than one contact point at a time. If no signals are heard, set the switch arm N on contact point 2 and again move the switch arm O over all of its contacts. Proceed in this manner until the transmitting

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station is heard. This is called "tuning" the primary circuit.

The tuning of the secondary circuit is the next operation. Set the secondary switch Z on contact point 1 and turn the knob of the variable condenser C so that the pointer moves over the entire scale. If now signals are heard, set the switch on contact point 2 and again turn the knob of the variable condenser so that the pointer moves over the entire scale. Proceed in this manner until the signals are loudest, being careful to see that the ends of the switch arms touch only one contact point at a time. Next slide the coil tube S (secondary) in and out of the coil tube P (primary) until the signals are made as loud as possible. This operation is called changing the "coupling." When the coupling which gives the loudest signal has been secured, it may be necessary to readjust slightly the position of the switch arm O, the position of the movable coil tube S and the "setting" of the variable condenser C.

The receiving set is now in resonance with the transmitting station. It is possible to change the position of one or more of the switch arms, the position of the movable coil tube and the setting of the variable condenser in such a manner that the set will still be in resonance with the same transmitting station. In other words, there are different combinations of adjustments which will tune the set so that it will respond to signals from the same transmitting station. The best adjustment is that which reduces the signals from undesired stations to a minimum and still permits the desired transmitting station to be heard. This is accomplished by decreasing the coupling (drawing coil tube S farther out of coil tube P) and again tuning with the switch arm O and the variable condenser C. This may also weaken the signals from the desired transmitting station, but it will weaken the signals from the undesired stations to a greater extent, provided that the transmitting station which it is desired to hear has a wave frequency which is not exactly the same as that of the other stations. This feature of the radio receiver is called "selectivity."

¶ *"Fighting Fire by Radio"—where and how the Forest Service has been using wireless successfully and saved Uncle Sam millions of dollars—will appear in the next issue of* POPULAR RADIO.

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WHERE YOUR RADIO CALL LETTERS ARE ASSIGNED

This is the inner sanctum of Uncle Sam's radio office—officially designated as the "Radio Service, Department of Commerce"—and the official at the extreme right is Mr. W. D. Terrill, the man who decides what call letters shall be. How the system works, and what your call letters signify will be described in the next issue of POPULAR RADIO.

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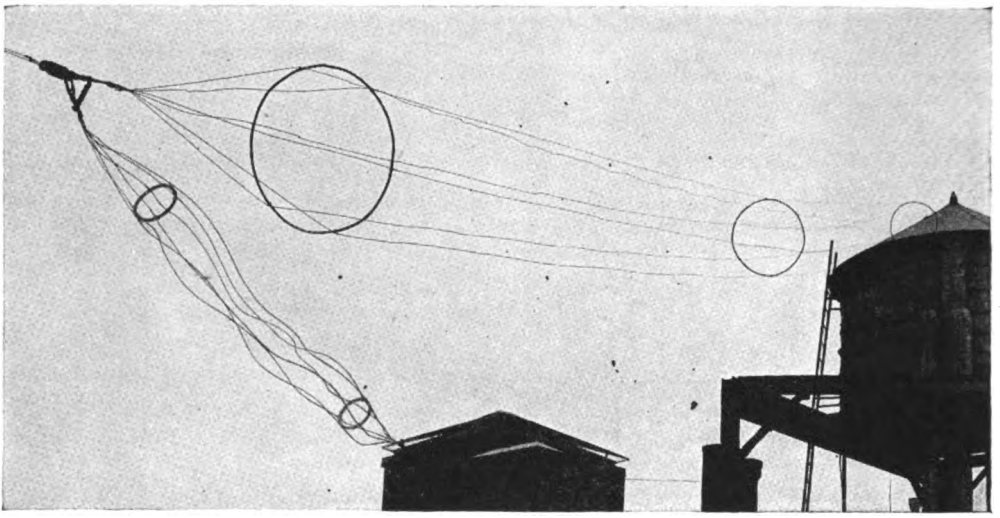

From a photograph made for POPULAR RADIO

The carefully designed and skilfully made cage antenna on the roof of an apartment building.

An Amateur Who Hears Europe

Have You Ever Heard Station 2BEA Transmit? Here Is a Description of Its Radio Equipment

By RICHARD LORD

WHILE walking up West End Avenue, New York, my eye was attracted by a carefully designed and skilfully made cage antenna, located on a tall apartment building. It was obviously the work of an experienced amateur. I noted that the lead-in continued as a diminutive cage to the window insulator. One look at this shipshape piece of work convinced me that it would be worthy examination, so I got into touch with the owner.

The owner was Mr. William Schweitzer, operating station 2BEA, an amateur of experience with a sound knowledge of the principles of radio.

The first C.W. transmitter which Mr. Schweitzer had operated consisted of four 5-watt tubes. With this small power output he did extraordinary work. On one occasion he was copied in Jefferson City, Missouri, a distance of 1,200 miles, by daylight.

Recently the 5-watt tubes have been replaced by a home-made set that employs two 50-watt tubes to generate the continuous waves. The plate potential is supplied from the secondary of a step-up transformer rectified by means of two Kenotron tubes. The actual voltage supply to the plates is approximately 1250. The circuit used is a Colpitts, employing capacity coupling between the plate and grid circuits.

The evening I called the static was unusually heavy for an early March evening, but a good deal of traffic was handled southwards. Savannah, Georgia, was raised on the first call and messages were put through without repeats.

The relay receiver is a Grebe CR4 with a vacuum tube detector and two stage audio frequency amplifier.

In addition to the relay equipment, Mr. Schweitzer has an excellent long wave apparatus for trans-Atlantic and trans-Pacific reception. The long wave tuner is a conventional honeycomb unit with the

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primary and secondary inductances shunted by a pair of very fine Kloster design condensers. A special long single wire antenna is used for long wave reception. The incoming energy is first amplified by three stages of radio frequency amplification. The radio frequency amplifier was especially constructed by Roget, of Paris; it employs three French valves and is resistance coupled. This device is remarkably silent in operation and very compact.

The magnified current is then supplied to the receiving tuner. The output in turn is passed through three stages of audio frequency amplification. The three stage audio amplifier is also built by Roget, and employs French tubes. Of course, one will readily believe that this equipment brings in signals of extraordinary strength. Ample energy is received from any of the stations generally copied on this side to operate the Morse relay recording device, which is a part of the station's equipment.

The radio station is located in a little building on the roof. In order to be able to hear the signals in the apartment, ten stories below, Mr. Schweitzer uses a Magnavox, which is supplied through a wire line running to the station. A step-down transformer is used to couple the output of the receiving set with the Magnavox. The music from the Newark broadcasting stations can be heard more than a block from the apartment when the Magnavox is on the windowsill.

Although there is much expensive equipment in the station, the remarkable results obtained are not dependent upon this equipment; they are due to the skill and careful workmanship which are displayed in the assembling and construction of the units. The 100-watt C.W. transmitter has been constructed in its entirety by Mr. Schweitzer.

From a photograph made for POPULAR RADIO

Good results from your radio set may be obtained not alone from good apparatus but from proper installation and maintenance—as William Schweitzer has demonstrated with his station 2BEA, a part of which he built himself.

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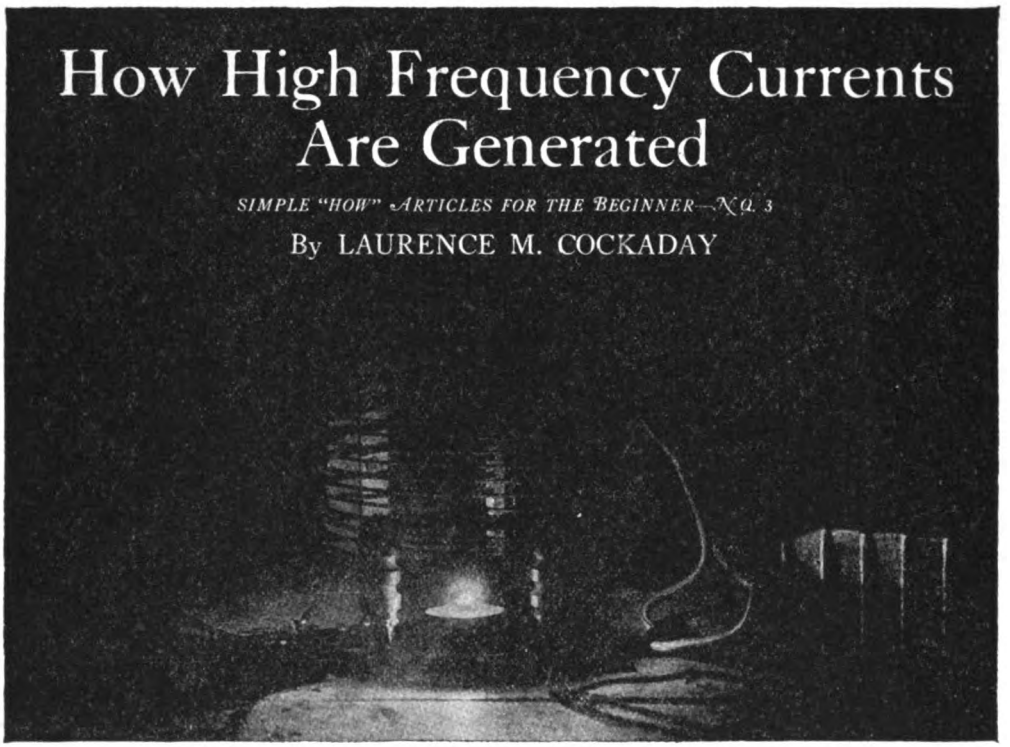
How High Frequency Currents Are Generated

SIMPLE "HOW" ARTICLES FOR THE BEGINNER—No. 3

By LAURENCE M. COCKADAY



From a photograph made for POPULAR RADIO

This picture shows a spark jumping the gap. The large coil (in the rear) and the enclosed condenser (at the right) comprise an oscillating circuit.

IN the two preceding articles we have learned how electricity is generated and what it is; we have acquired a general idea of what a radio wave is and how it is sent out through space. We have been told that the radio wave is set up in the vicinity of a transmitting antenna only when a current of extremely high frequency is caused, by some means or other, to flow back and forth, or oscillate through an antenna circuit. This radio wave has a definite wavelength for every given frequency of current that is caused to flow in the antenna circuit.

In this third article of this series we will delve into the seemingly mysterious methods employed for producing these high frequency currents and also into the methods of controlling the frequency of these currents whereby a transmitting station may "tune" itself to a wavelength alloted to its use by the government. The case that we will now study is the generation of high frequency currents by the spark discharge method.

—EDITOR

MANY of us who have walked past the radio cabin on a steamer have heard the crashing, sparking sounds that issue from the radio transmitter. Some of us have seen the sets in operation. Most of us have perhaps turned away with the thought: "Well, radio certainly is a wonderful thing, and it must have taken some brain to work out the idea, but it's beyond me."

This, however, is not so. Anybody can understand the mechanics of radio if given the right instruction.

In the last article we became slightly familiar with two electrical instruments —the inductance or coil, and the condenser. We learned that these two pieces of apparatus were storehouses of energy. The coil we found had the ability to store up electromagnetic energy. This meant that the coil produced an electromagnetic field around itself that was similar to the field set up around a steel permanent magnet. The condenser on the other hand, by having all the electrons drawn off one plate and crowded on the other plate, became "charged." This caused one plate to be positive, and the other to be

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negative. The plate which contained all the electrons was the plate that was charged negatively. These two charges caused the "dielectric" or insulation between the two metal plates to be placed in a stressed or strained condition; in other words, an electrostatic field was set up in the insulation.

We will now connect up these two instruments with a spark gap and show how they, in combination, will cause wave trains of high frequency currents to be generated and how they also can be varied in size so that the frequency of the oscillations can be controlled at will, thus controlling the wavelength emitted from the transmitting set of which they form a part.

If we connect a wire to one plate of a condenser, which is made for high voltages, and which is diagrammatically shown at C in Figure A, and also connect the other end of this wire to one electrode of a spark gap SG, and connect the other plate of the condenser C to another wire which is attached to one end of a coil L, and further connect the other end of the coil to another wire which is in turn connected to the remaining electrode of the spark gap SG, we have connected up a regular oscillating circuit such as used by spark radio telegraph stations for generating the oscillations necessary for the production of the Hertzian or radio waves.

Now we will continue and make the circuit oscillate for our inspection in a very slow manner so that we may comprehend the workings clearly. Of course this will be unnatural, but it will serve to show us the functioning of the circuit in much the same way as motion pictures are slowed down so that the observer may see each individual action.

We will first place a charge on the condenser C; a positive charge on the upper plate and a negative charge on the lower plate, Figure A. As we have already learned, a condenser when charged, contains a store of energy which is in the form of electrostatic electricity, or stationary electricity.

When a condenser is charged in this manner it tries to discharge and thus neutralize the charges on the plates. This discharge cannot take place unless the condenser has some external, electrically conducting path through which the electric current may run. This conducting path may be a wire attached from the positive plate to the negative plate. Inspection of Figure A shows that we have these conditions fulfilled except for one point—the air gap between the electrodes of the spark gap. Therefore, if we wish the electric charges on the condenser to discharge through the circuit we must place a high enough voltage on the plates so that the resistance of the air between the electrodes will be overcome and a spark allowed to jump across the gap. Then we have a complete conducting circuit from the upper plate to the lower plate of the condenser and a cur-

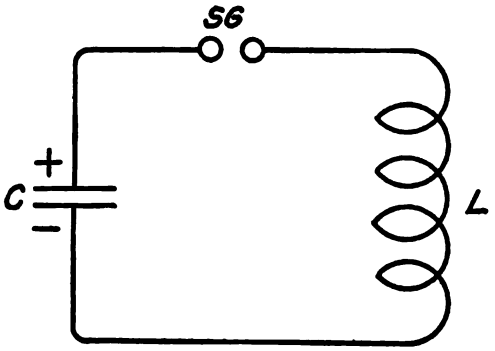

FIGURE A

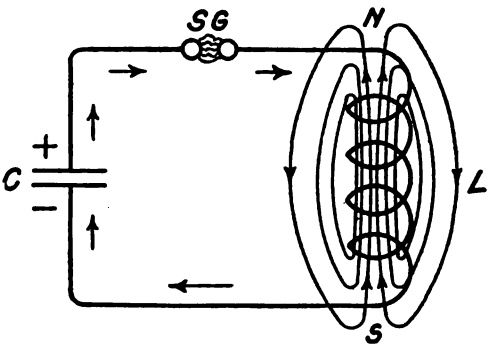

FIGURE B

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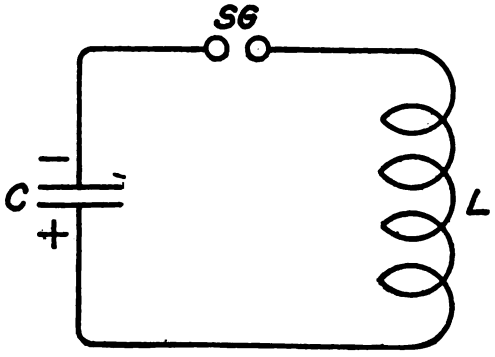

FIGURE C

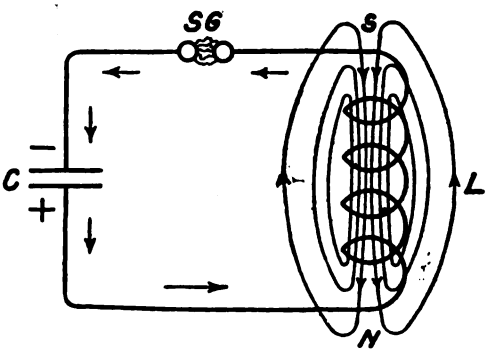

FIGURE D

rent of electricity is caused to flow around through the circuit as indicated by the arrows and the spark shown jumping the gap in Figure B. This current is instantaneous and is shown as a positive impulse making up one half a cycle in Figure E.

We have learned that when a current is allowed to flow through a coil, a magnetic field is set up around the coil, which causes it to become an electromagnet with one end of a north polarity and the other end south, as shown at L in Figure B.

When the current has flowed through the circuit, the charges that were on the condenser C have become neutralized and therefore the current ceases. When this happens the magnetic field that has been set up around the coil L collapses; that is, the magnetic rings fall back on the surfaces of the wires and a peculiar effect is noticed; a voltage is induced in the coil which is positive in the direction that the current was running.

This means that the condenser C receives a reverse charge immediately after the current from the initial charge has ceased to flow.

This second charge places a positive potential on the bottom plate of the condenser and a negative charge on the top plate, (See Figure C). This charge is not as strong as the first charge, however, because there is some energy lost due to the fact that the current must overcome the resistance of the wire and that of the air through which the spark must be forced.

When this second charge on the condenser reaches a high enough value to again break down the spark gap, a spark occurs across the gap and a second current flows through the circuit, in the opposite direction to the first current (See Figure D). This current forms a negative impulse which is shown in the diagram, Figure E, as the second impulse of the first cycle. Again the coil sets up a magnetic field around itself, only this time the top of the coil is of a south polarity and the bottom of the coil is north.

When this field collapses at the cessation of the second current the coil induces the third charge on the condenser which is in the same direction as the original charge.

The same cycle of events then takes place and the current oscillates back and forth through the circuit one way and then the other, but the successive oscillations become weaker and weaker until they die out (See Figure E).

Remember, however, that in our study of these oscillations we have considered them as slow oscillations; in reality they take place in the twinkling of an eye—much faster in fact. One of these series of current wave trains, as they are called, would look to the human eye, like one single crackling spark across the gap. The modern radio transmitter uses frequencies up to 2,500,000 cycles a second, which means 5,000,000 reversing im-

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pulses a second, jumping the gap. Little wonder that they look like one single spark!

We now have a general idea of how this simple little circuit, composed of these simple instruments, can perform this miracle of electrical speed and motion without any mechanical moving parts. Now we shall see how we can control the frequency of these generated impulses, by varying either the size of the coil or the size of the condenser.

We may liken the condenser to a pitcher of water. We know that if we have a small pitcher, a certain sized stream of water will require a certain length of time to fill the pitcher. If we use a larger size of pitcher, and hold it under the same stream of water, it will take a greater length of time to fill it. It will also take a longer time to empty the larger pitcher than it will take to empty the small one.

We can also liken the coil to a coiled tube that we can pour the pitcher of water into. A certain length of time will be needed for the water to wind around through the convolutions of the coiled tube and finally find its way out of the bottom. If we make the tube twice as long, it will take twice as long for the water to run through.

Now apply this idea to the electrical circuit. If we use a larger condenser C, it will take longer for it to charge and discharge, making the currents that oscillate through the circuit to last longer. If they last longer, there cannot be as many each second. Therefore if we increase the capacity of the condenser we get fewer impulses a second, thus decreasing the frequency of the oscillations and increasing the wavelength that is emitted from the antenna to which this circuit is coupled.

Or we may get the same result by increasing the number of turns of wire in the coil, and the current will take longer to run through it, so to speak; again we have less impulses a second or a higher wavelength. Increasing either the capacity of the condenser or the inductance of the coil, increases the wavelength. This latter method is generally used for transmitting stations, as it does not vary the power of the set to such a great extent while changing the wavelength, as varying the size of the condenser varies the power greatly that the circuit uses. A given size of condenser will hold a given charge, and if it is varied in size the charge varies in size also.

The coils are generally made with a large number of turns of heavy wire on them and a sliding contact slides over the surface of the wire and picks out the desired number of turns to be left in the circuit to obtain a frequency that corresponds to the desired wavelength.

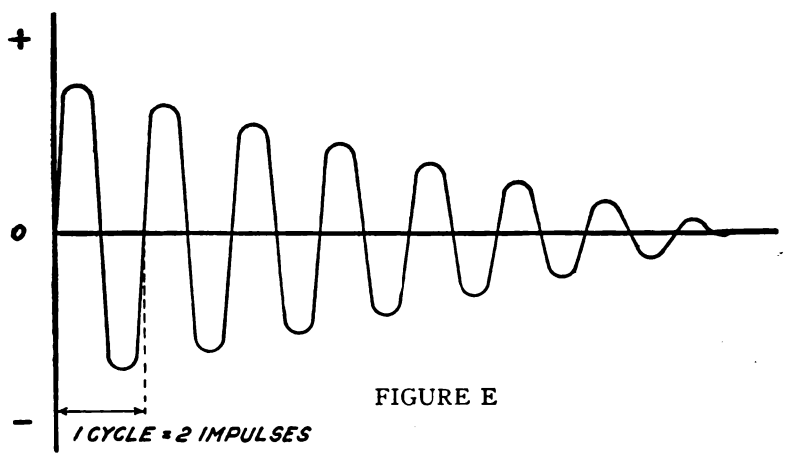

FIGURE E

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In this way radio transmitting stations are tuned to the wavelength that they are required to send out on by governmental regulation.

So we find that the whole scheme is, after all, simple. The only feature that made it seem mysterious was the fact that we had no way of telling just what took place when the sparks "jumped the gap," until we analyzed the whole process.

In a future article we will show how these impulses are transferred to the transmitting antenna; then we will see that the coil plays a double role in the radio circuit.

Pointers for Preventing Interference

By C. A. BRIGGS

AMATEURS who operate radio sets for receiving music should tune and stop their bulbs from oscillating as quickly as possible, or they may interfere with their neighbor's entertainment.

When the bulb of a receiving set is oscillating it generates a high frequency alternating current. In this condition it constitutes a small transmitting station which may send out waves sufficiently strong to be picked up by other receiving apparatus in the vicinity. Indeed, communication may sometimes be carried on over short distances by utilizing this very fact.

While listening in on music, lectures and other broadcasted entertainment the amateur sometimes hears a smooth, whistling note that changes its pitch. As many as three such interferences have been heard at one time at a station. These sounds may be caused by nearby listening stations which are picking up the telephone wave and adjusting it in. Telephone waves are best picked up by starting the detector bulb to oscillating and then hunting about over different wavelengths until the whistle or squeal of the radio wave so familiar to radio operators is found. The different adjustments are then arranged to bring the response to the point of maximum efficiency; the final setting is generally such that the receiving tube is just on the point of, but not quite, oscillating.

Sometimes the telephone waves are received while the tube is kept oscillating; in that case the sounds may be loud but somewhat distorted and broken up.

For receiving code signals on continuous wave transmission it is necessary to have the receiving set oscillating, as the whistling note is the signal received. In such cases interference by other receiving sets may not be so serious. The quality of the sound is not important and the effect of the interference of receiving stations will not break up the dots and dashes of the code but merely add a continuous note to the intermittent notes that come from the distant station. An operator may sometimes stop his own tube from oscillating yet receive the incoming code signals with the aid of his neighbor's oscillating tube. This method, however, is not recommended as the other operator is sure to change his adjustments and lose the signal at a critical time.

The type of set known as the "single tuner circuits" are generally credited with being the worst offenders for producing interference. In these sets what constitutes the primary and secondary circuits of more complicated apparatus are in a sense combined, and the closer union of the tube circuit with the aerial is said to cause the set to radiate much more strongly than is otherwise the case.

It is well, therefore, for everybody who operates a radio receiving set to keep these tips in mind, and when he picks up telephone waves to make the necessary adjustments and stop the bulb from oscillating as promptly as he can.

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The "Soup-Plate"

A Novel Type of Transmitter that Reverses the Principle of the Loud Speaker

By FREDERICK SIEMENS

THE problem of getting a large volume of sound converted into electricity for use in modulating the high-power transmitting stations that are now being used for radio broadcasting has become of increasing importance during the last year.

Several systems have been worked out to attain this result, but most of them have this serious disadvantage: while they produce a large amount of voice-controlled electricity, at the same time they distort the voice wave that is impressed upon them. Thus the reproduction is not as clear or as faithful as it should be.

One particular method that gives a very good quality of speech and relies upon the electromagnetic principle for its action is illustrated by the accompanying picture. The speaker or singer throws his voice into the "soup-plate" transmitter, as it has been nicknamed, which consists of a large paper diaphragm that vibrates in accordance with the voice wave that impinges upon it. The center of this diaphragm is attached to a moving coil which is placed in the magnetic field of a powerful electromagnet. When the diaphragm vibrates, the coil moves back and forth with it; this motion causes it to change its position in the magnetic field of the electromagnet. These motions of the coil back and forth, which conform with the voice waves, cause electric currents to flow in the coil which also are controlled by the voice waves. In this way the voice wave is changed from a sound wave into an electrical wave without depending on the old style transmitter which distorts so much and which uses carbon grains which are pressed tightly together or loosely as the voice causes them to vibrate.

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Arthur Stringer, the well-known poet, recites his Irish poems by radio, from the broadcasting station at Fort Wood

The voice currents produced by the new method are remarkably true in following the complex voice vibrations as used by everybody in ordinary speech, and are remarkably effective in the reproduction of music. The current obtained from this instrument is magnified or amplified by means of vacuum tube amplifiers, somewhat similar to those used by the amateur, except that the tubes used are larger and are known as power amplifiers.

The cylindrical object that is shown, supported from the rim of the cone-shaped diaphragm by the three radial supports, contains the electromagnet and the moving coil.

The principle of the new transmitter is just exactly the reverse of the loud-speaker used for receiving. In the latter the electrical energy is converted into sound and in the transmitter the sound is converted into electrical energy. The same apparatus can be used for both purposes with slight modifications.

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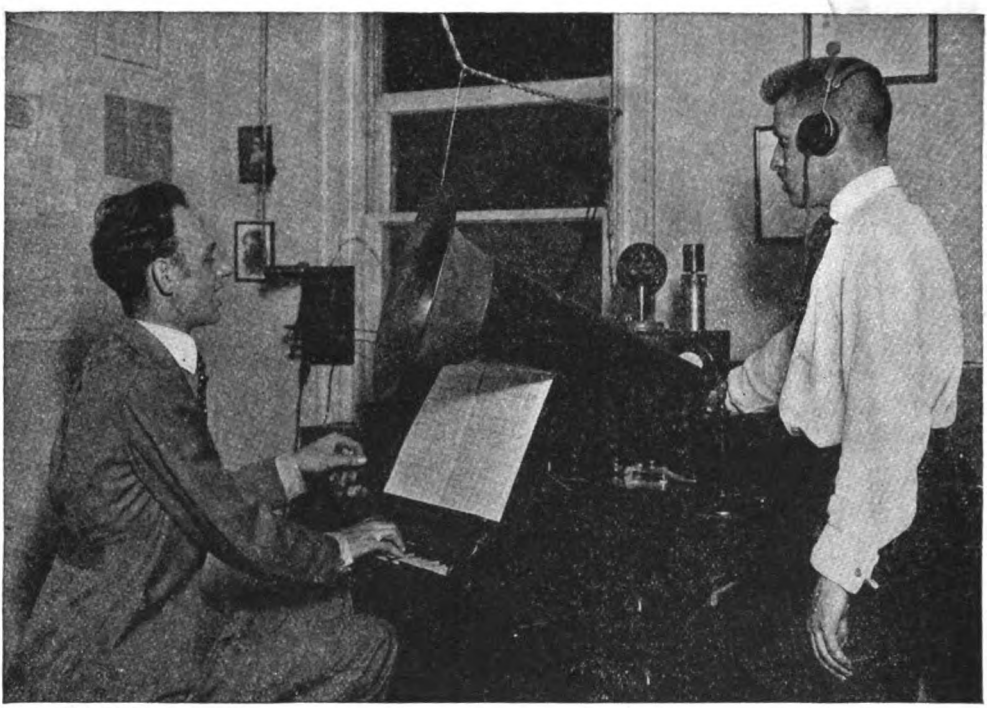

George Grantham Bain

An amateur who sings a copyrighted song by radio for the entertainment of fellow fans expects no financial returns from his efforts. But the use of such music by professional artists engaged by business houses is raising some knotty problems.

DOES BROADCASTING A SONG CONSTITUTE

"A Public Performance *for* Profit?"

If so "Who Will Pay the Piper"?—and How?—Ask the Music Publishers, Authors and Composers

By E. C. MILLS

DOES the singing of a song over the radio—more particularly the singing of a song of which the words and music are copyrighted—constitute a "public performance"? And if it does, is that performance "for profit"? And if it is for profit, who makes that profit and can the owner of the copyright collect payment for such a public performance?

These are only some of the questions that the amazing development of the radio and the extension of broadcasting programs have raised so suddenly that the song-writers and publishers have scarcely had time to determine just how their legal rights as well as their pocket books are being affected. According to the opinion recently rendered by Nathan Burkan of the American Society of Composers, Authors and Publishers, the singing of a copyrighted song by radio does in effect constitute a public performance for profit, and the owners of the copyright are entitled to revenue therefrom. Just how royalties may be collected, however, has not yet been determined.

A copyright on a song (or on any musical composition) vests in its proprietor three distinct rights:

(1) The right to print and multiply printings of the work;

(2) The right to control the mechan-

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ical reproduction thereof (such as phonograph records and player-piano rolls), and

(3) The right to publicly perform or license the public performance (for profit) of the copyrighted work.

All of these rights are exclusive.

These rights are based upon the Copyright Act of 1909; it and the preceding Acts granting Copyright having been enacted pursuant to a clause in the original Constitution of the United States which provides that Congress should have the power, for the encouragement of the arts and sciences, to enact such legislation. The broadcasting by radio of concerts, for the entertainment of thousands (and soon, apparently millions) of owners of receiving apparatus, is, in the opinion of the authors, composers and publishers, a public performance for profit.

It is true that the listeners-in on these concerts do not pay to the broadcasting stations any fee for the service; nor does it seem immediately practicable to arrange any basis upon which broadcasting stations might charge a fee to the owners of receiving apparatus.

If broadcasting is to be continued however, it is obvious that it must pay commercial profits to those who operate the stations. Under the present conditions these profits must flow from the sale of receiving sets. If broadcasting does not pay as a commercial enterprise, it will be discontinued. As an alternative, it may be supported by the municipal, state or Federal governments.

If broadcasting pays as a commercial venture of a private concern, and the broadcasting of copyrighted musical compositions constitutes a part of its service, then obviously the music that is being used for purposes of profit and those who create such music are entitled to share in such profits.

Radio has developed in such an amazing and spectacular manner that it promises to become the greatest factor the world has ever known for the dissemination of information and education of the whole people. The position of musical copyright proprietors, including authors, composers and publishers, is now and will be in the future to lend their support to any cause or purpose which promises so much for mankind's benefit, and they therefore do not oppose radio, nor would they handicap or hamper its logical development.

HOW CAN THE RADIO PROFIT THE COMPOSER?

"The widespread use of music in broadcasting," states the author (who is the chairman of the Executive Board of the Music Publishers' Protective Association), "is materially decreasing the earnings of authors and publishers." What can they do about it?

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On the other hand, the widespread use of music in broadcasting is bound to affect the earnings of the authors and publishers, it is even now decreasing them materially and promises to do so to a much greater extent. Fair and just recognition of the music writers of the country will make it necessary that they be reimbursed in some way by the radio which at present is reducing their earnings.

A basis for the charging of royalties upon such copyrighted music as is used in these broadcasted concerts has not yet been worked out. The copyright owners have felt that they should not place any obstacle in the way of the development of this art which promises so much. But in due course a plan for charging the broadcasting stations for the use of the product from which they derive their profit will presumably be worked out.

If the contention of the music publishers that the broadcasting of copyright music in the prevalent manner is a "public performance for profit" is correct, then a technical infringement of copyright is committed every time such a composition is broadcasted without a license from the copyright proprietor. The publishers are in communication with the various broadcasting station proprietors, and have every reason to believe that their position in the matter is one of entire fairness, and that they will frankly recognize the rights of copyright proprietors in this matter and work out a plan of compensation on a fair basis.

Photo by A. M. Vinje

A UNIVERSITY PROFESSOR LECTURES TO THE WHOLE MIDDLE WEST

On the principle that the citizens of the State of Wisconsin who support the University of Wisconsin are entitled to such privileges as the institution can extend to them, the officers of the university are carrying on "certain forms of extra-mural teaching" by means of radio broadcasting. This picture shows Prof. Alfred B. Haake delivering a talk on economics. Some of the lectures have been heard as far west as the Rockies and as far east as New England.

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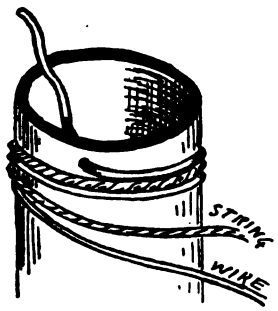

FIGURE 1

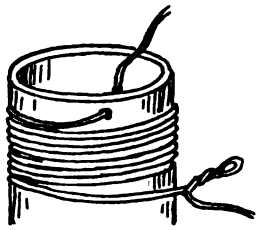

FIGURE 2

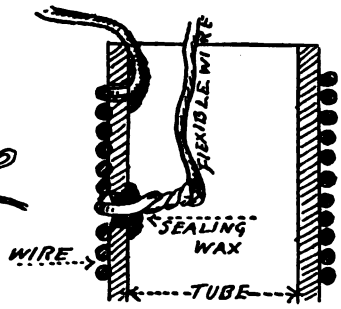

FIGURE 3

Illustrated with pen-and-ink sketches by the author from a home-made apparatus which he built himself

How *to* Make a Loose Coupler Coil

Another of the Practical and Popular "How to Make" Series of Articles for the Radio Novice

By A. HYATT VERRILL

ALTHOUGH vario-couplers, variometers and other instruments have largely taken the place of the older and simpler loose-coupled tuning coils, especially in the more expensive and ready-made sets, still, a well-made, loose-coupled coil is a useful device and will give excellent results. Moreover, it is far easier to make a loose-coupler than other forms of vario-coupler tuners; any one with the least mechanical ability and a little patience may build an efficient coil of this sort at a small cost.

No expensive or special tools are required with the exception of some twist drills, either used in a geared breast drill or a bit-brace, and the only materials needed are some formica or other composition tubes, some half-inch wood, wire, a few binding posts, a multiple point switch, half a dozen ⅛-inch by 1-inch brass machine screws with nuts and washers to fit, a piece of ¼-inch round brass rod about 18 inches long, a piece of ¼-inch square brass rod a little more than a foot in length, a small strip of spring brass and a piece of square brass tubing ¼-inch inside and 2 inches long. Formica or other composition tubes are suggested; while pasteboard tubes or wooden cylinders may be used as the foundations for coils, they are not advisable. They do well for experimental work or rigging up a temporary set, but even if shellacked or soaked in paraffine they will still absorb moisture, and this detracts from the efficiency of the coil. In our climate, where the air is damp and humid in summer and the houses that are heated by artificial means are dry in winter, wood and cardboard will swell, shrink or warp and eventually ruin the coil. Accordingly, if you intend to make a good coil, get tubes that will serve you well and will endure; good work is worthy of good foundations.

The exact size of the coils is not important as long as the diameter of the smaller one is a trifle less than the diameter of the outside coil, so that it may be slipped within and yet leave at least ⅛-inch all around. If the larger tube is be-

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tween 2½ and 3½ inches in diameter and from 6 to 8 inches long, it will do very well and the smaller tube should be the same length.

The first step is to wind the larger or primary coil. This may be done either with double cotton covered, enameled or bare copper wire about No. 24 in size. Make a small hole about three-fourths of an inch from each end of the tube; thread about 6 inches of the wire through this and fasten the wire on the inner side of the tube with a drop of sealing wax. Then wind the wire on smoothly and evenly. If you are using insulated wire, merely wind on the turns side by side, but if you are using bare wire wind it on with a cotton string or twine between each turn of wire, as shown in Figure 1.

When you reach the hole at the opposite end of the tube, run the wire through, fasten it inside the tube with sealing wax and snip it off close.

When you wind a tube, you will find it far easier for two to work than to do it alone. One can then hold the coil as the wire is wound on while the other can unroll the wire and keep it free from kinks. If you buy a reel or spool of wire this may be hung up on a nail or peg and may be reeled off easily without fear of kinking. Also, if you have a lathe you will find it very easy to attach the tube to the lathe and by revolving the tube wind the wire on easily and smoothly. To fasten the tube in the lathe, slip it over a cylindrical piece of wood, fasten it lightly by small screws through holes close to the ends of the tube and place the chucks against the wooden cylinder.

To wind the smaller or secondary coil is not a simple, for this must be tapped at intervals of every twenty turns. Start the wire in the same way as on the large coil and wind on twenty turns. Then, make a small loop or twist in the wire as shown in Figure 2. Scrape off the insulation and attach a piece of flexible insulated copper wire about a foot long. Make a good connection (keep the wires bright and twist them firmly together), and then, just where the tap comes on the tube, bore a hole, run the flexible wire through, pulling the loop in by gently pulling on the end of the flexible wire at the end of the tube and drop a bit of sealing wax upon the wire where it enters the hole (Figure 3). The only care needed in doing this is to have the hole large enough to allow the tap to pass through freely, to be careful and not kink the wire on the outside of the coil and to hold the wire wound on the coil in place while making the tap and pulling it through the hole. You may have a bit of trouble with the first tap, but if anything goes wrong you can unwind the first twenty turns and start over again without much trouble—and it is a good plan to become adept and to make a neat job of this first tap before continuing to the next.

After the first tap is made the others will be easier, for by carefully measuring the distance from the first turn of wire on the tube to the hole for the tap you can measure off the spaces on the tube for the other taps and make the holes ahead of time. After the first tap is successfully made, continue winding for the next twenty turns, make a second tap the same way and so on to the end of the coil, where the wire should be run through a hole, fastened on the inside of the coil with sealing wax and left with about a foot of loose wire free.

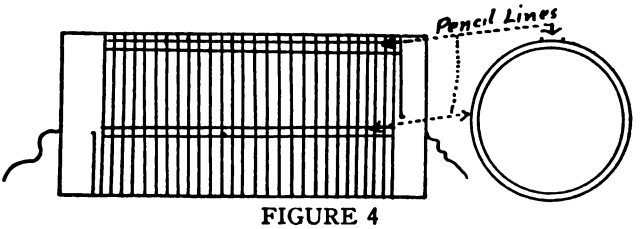

FIGURE 4

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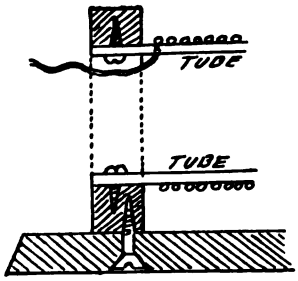
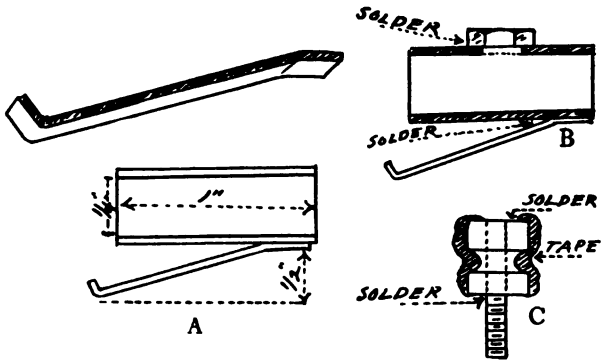


FIGURE 5



FIGURES 6, 6A, 6B AND 6C

The next step is to mount the coils. Use either Bakelite, fibre or well-seasoned white wood for this. If you have a jig-saw or a small keyhole saw, you can readily do everything yourself, but if not you can get some nearby carpenter or cabinet maker to cut the pieces for you. Assuming the large coil is 3 inches in diameter and 7 inches long, you will require a rectangular piece 5 by 15 inches for the base or panel; two pieces 4 by 4 inches for the primary or large coil support; two pieces 3 by 3 inches for the supports for the secondary or smaller coil and two circular pieces or discs just the right size to fit snugly into the smaller tube.

The two pieces 4 by 4 inches to support the primary coil should have circles or holes cut in each; the circles should be just large enough to admit the bare ends of the large coil. Have all these pieces of wood smoothed and sandpapered, bevel the edges of the square and rectangular pieces and give them a coat of stain and let them dry. Then sandpaper again, give another coat of stain and when dry give two coats of valspar varnish or shellac. While the stain or varnish is drying you can go on with the other parts of the loose-coupler. Along the large coil (if wound with insulated wire) mark two lines ¼-inch apart as shown in Figure 4, using a ruler to get them straight. Be sure that they are true and parallel with the axis of the coil. At 90 degrees from these, or at one side if the first lines are uppermost, draw two more lines parallel with the first. Then, with a red-hot iron, burn off the insulation along these two marks between the pencil marks, ¼-inch apart. If the wire is cotton covered you may overcome any tendency of the cotton to

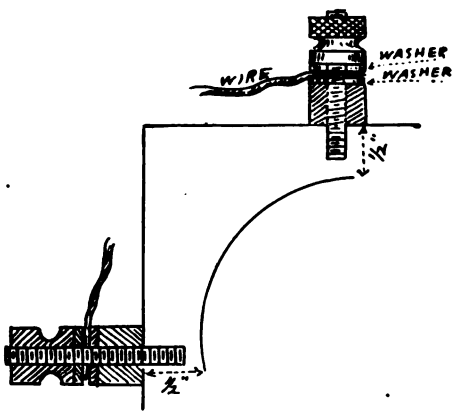


FIGURE 7

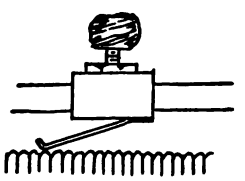


FIGURE 7A

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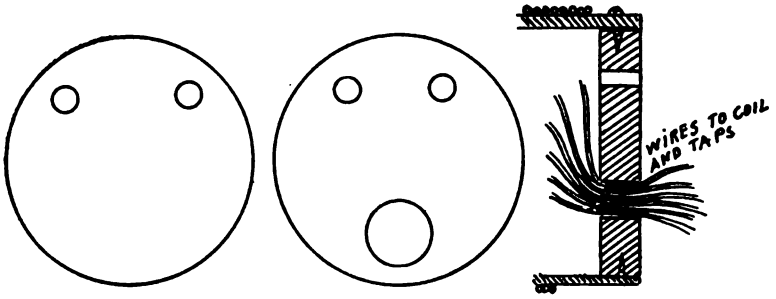

FIGURE 8A FIGURE 8B FIGURE 8C

burn irregularly from the lines by running a damp rag along the lines, or you may clean off the insulation with a sharp knife. However you do it, clean the wires until bright; if by any chance they bend or slip together, wind a string between the turns. If you have used bare wire, this burning off of the insulation will of course be unnecessary and for that reason I advise using bare wire and keeping the turns separated by twine, which may be removed after the coil is wound, although it does no harm if left there.

The coil may then be mounted by attaching it to the uprights by small screws driven through the bare end of the coil into one upright piece, as shown in Figure 5. This upright should be attached to the base, the coil fastened to it and the other upright slipped over the opposite end of the coil and fastened to the base but not to the coil. If holes are bored in the proper places through the base and into the upright before slipping it on the coil, there will be no trouble in securing it in position.

Next, cut two sections of the square brass tubing, each 1 inch in length and cut two strips of spring brass about 3/8 of an inch wide and 1/32-inch thick and bend in the form shown in Figure 6. Solder one end of each to each of the sections of square tubing as shown in Figure 6A. Bore a hole, a trifle more than 1/8-inch in diameter, through the opposite side of each section of brass tubing and over each solder a brass nut to fit the 1/8-inch brass screws. The easiest way to do this is to clamp the tube in a vise, fit a wooden pin through the nut, insert the end of the peg in the hole in the tube and while holding the nut in position solder it, as shown in Figure 6B. Then, cut the heads from two of the 1/8-inch brass screws, leaving about 3/4 of an inch of the threaded shank, screw a thumb nut or knurled nut, such as you may obtain from an old dry battery, on the screw and solder it. Smooth off the solder and any projecting parts of the screw above the thumb nut with a file and wrap a little adhesive tape around the thumb-nut. (Figure 6C.)

Now slip a piece of the square brass rod through one of the sections of brass

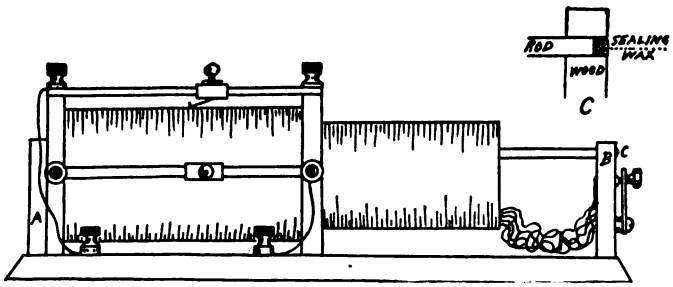

FIGURE 9 AND 9C

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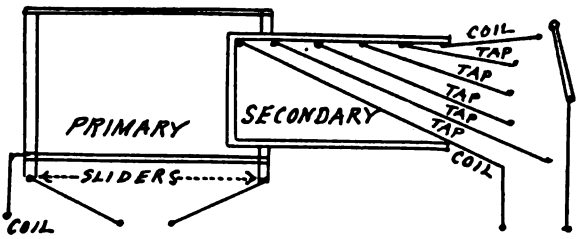

FIGURE 10

tube and lay the rod along the coil from one upright to another over the bared space on the coil wires (if they are insulated wires); when it is exactly parallel with the bared space (or with the coil if bare wire has been used), mark with a pencil where the rod comes on the uprights and cut the rod to the right length to come even with the outer edges of the uprights. Bore a ⅛-inch hole through each end of the rod, make a slightly smaller hole in the uprights under the holes in the rod, and screw one of the ⅛-inch screws into each of these. Clip off the heads of the screws, slip the rod over them, place a washer on each screw and secure the rod by means of a binding nut as shown in Figure 7, first placing a wire terminal under the washer on one screw. If you have done all this according to directions the spring on the under side of the slider should bear firmly against the wires on the coil. Then, by screwing the brass screw with the thumb-nut soldered upon it (Figure 6C), into the nut soldered to the slider you can secure the slider in any position and can move it back and forth by means of the tape-covered nut as shown in Figure 7A.

The other slider should be mounted on its rod on the uprights in exactly the same manner, but over the other bared space of the coil (or, if bare wires are used, on one side of the support parallel with the axis of the coil.

The next step is to mount the secondary or inner coil. This is done by first securing the two circular pieces of wood in a vise or clamp and boring two holes ¼-inch in diameter through both pieces a little above their center, as shown in Figure 8A. Bore another hole, large enough to admit all the tap wires and the two ends of the coil wires, through one of the wooden discs (Figure 8BC). Secure this disc in one end of the coil (first drawing the wires through the hole made for them), by small screws driven through the bare ends of the tube, as shown in Figure 8C. Then place the other disc in the other end of the tube and by sighting through the ¼-inch holes align it with the first one. It may help you to do this if you draw pencil lines along the coil, parallel with the axis, from the two holes in the first disc; it is highly important to have the holes in the discs come in perfect alignment, as otherwise your coil will not move evenly and truly on its rods after it is assembled.

When the second disc is in the right position, secure it as you did the first by small screws. Then slip the ¼-inch brass rods through the holes in the discs and wrap the coil smoothly with heavy paper, wrapping the paper on until the coil fits snugly inside the larger coil without forcing it. Rub some chalk or crayon on the ends of the rods that run through the small coil and while holding one of the 3 by 3 inch pieces of wood against the support to the large coil, press the two rods against it and turn them about until the chalk has marked spots where the rods touch. Then, clamp the two pieces of 3 by 3 inch wood together with edges even and bore ¼-inch holes through both where the chalk marks show. Slip the pieces over the rods and secure them to the base. Fasten one at the end of the large coil and the other near the opposite end of the base (Figure 9AB). Remove

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the rods and the small coil. Remove the paper wrapping from the coil and holding the coil in front of the large coil, slip the rods through one upright, through the two end discs in the coil and through the other upright. Cut the rods so that they are not quite flush with the outer sides of their supports and secure them in place with sealing wax as shown in Figure 9C.

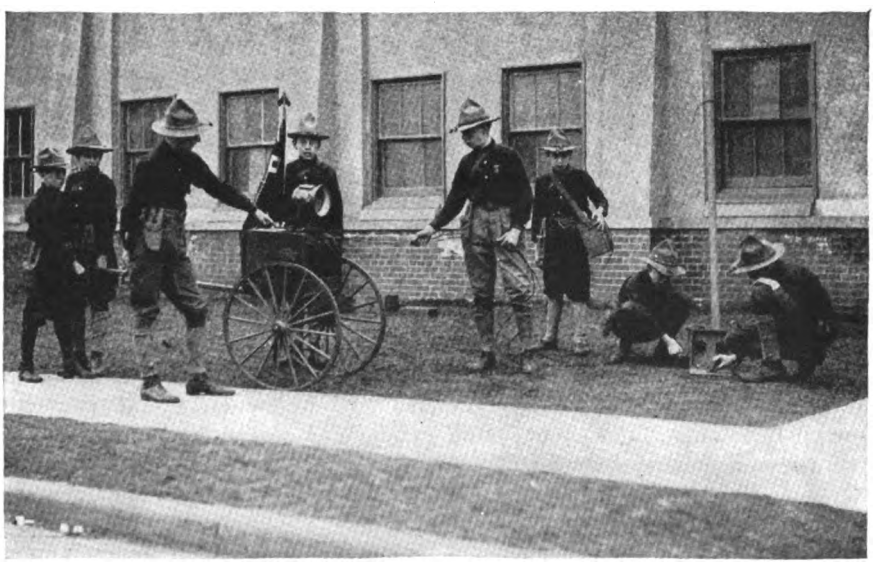
All that now remains to be done is to connect the various wires. Each of the tap wires and one of the end wires of the small coil should be carried to a separate contact on a multiple point switch which is best mounted on the upright as shown in Figures 9 and 10. If you prefer, you may place the switch on the end disc of the coil itself, but I have found this a bad plan, as in adjusting the switch you invariably move the coil somewhat.

The coil should move freely but not loosely. The other end of the coil wire should be led to a binding post; another wire should connect the switch arm to a second binding post and the free end of the wire from the large coil and the two wires from the slider rods should be led to other posts, all of which is shown in Figures 9 and 10.

Always remember to wind both coils in the same direction, to use flexible wire for the tap and coil leads on the secondary coil and be careful and accurate in your work.

Do *not* shellac the coils after winding and *never* use paint or enamel varnish about the coils or wires. Countersink all screw heads in the wood, leave no rough ends or jagged edges to metal or wood and try to make the finished coil a credit to your skill and to your workmanship.

¶ *The next article of this series will tell you how to make your own variable condenser at about half the cost of the ready-made devices which are on the market—but which are now so hard to find.*



WHAT THE BOY SCOUTS ARE DOING WITH RADIO

More than any other discovery or invention of recent times, the radio has entered into the activities of the largest and one of the most valuable organizations of boys in the world. How these scouts are making themselves proficient in this art, and how they are learning to use the radio in practical ways, will be told in an article by Armstrong Perry—in a near issue of POPULAR RADIO.

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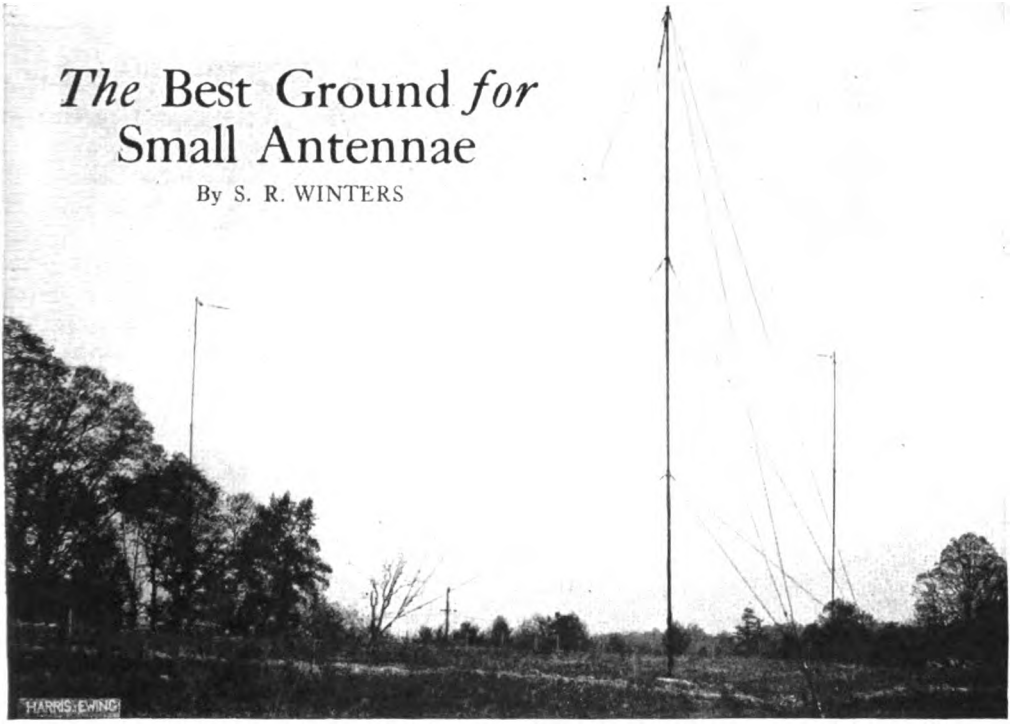
The Best Ground *for* Small Antennae

By S. R. WINTERS



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The lowest radiation resistance ever recorded in this country has just been attained by the use of a counterpoise ground system—a new development that makes extensive savings in electrical energy.

ON the theory that when a counterpoise is used with an antenna only low electrical resistances are possible, a series of experiments conducted by Dr. J. M. Miller of the Radio Research Laboratory, Bureau of Engineering, United States Navy Department, has abundantly justified the original conception. Measurements taken while the investigation was in progress revealed a surprisingly low minimum antenna resistance for a small antenna of 1.4 ohms, at 800 meters, and a ground and conductor opposition of only 0.7 ohms.

Novel experiments require unusual equipment. The experimental antenna was constructed near Connecticut Avenue in Washington, D. C., at a point where a slight rise in the elevation of the earth partly obscures from the view of passers-by, the physical equipment of the National Bureau of Standards, located on a commanding hilltop. Here on a vacant lot, with the nearest trees a hundred feet distant and an area unobstructed save by weeds struggling for existence, the masts of the radio installation tower skyward. These upright steel poles, fifty feet high, are three in number, and form a triangle, with a distance of a hundred feet to each side. The soil may be wealthy in humus for producing crops but is not at all favorable to the installation of equipment essential to transmission of wireless messages. Six inches below the surface of the ground, rock was struck, but the geological formation, fortunately, was pliable enough to yield to the blows of a pick.

The antenna was built in the shape of a triangle with radial wires attached at a center point, the wire was copper, No. 10, tautly drawn and insulated from the triangular-grouped masts by three 24-inch

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porcelain rod insulators. Originally each mast was insulated by three glass ball insulators placed under the foot and supported by nine guys, each of which was insulated near the ground by a porcelain egg insulator. The lead-in consists of a six-wire 12-inch cage of No. 16 wire. A buried ground system and a counterpoise were both investigated. The ground system embodies a circular trench, two feet deep and twenty feet in radius, circumventing the bottom of the lead-in circuit. Seventeen galvanized iron plates, two feet wide, were set on edge around the trench, overlapping each other by a margin of a few inches. One insulated wire is attached to each plate and retraces its course to the foot of the lead-in along the surface of the ground. A recent British publication favors a suspension of these wires above the earth, but experimenters in this country are not so positive as to the necessity of the English recommendation.

When the equipment was completed it was subjected to resistance measurements by the radio experts of the Radio Research Laboratory of the Navy Department, which is under the direction of Dr. L. W. Austin. During the first two or three days the electrical resistance of the ground conductor appeared to be declining; after four days a curve was plotted to show the exact ratio of the decreasing radiation resistance, a factor in the interest of efficiency. The antenna capacity was 700 micro-microfarads. The resistance curve indicated a ground and conductor resistance of approximately 2.5 ohms. Taking into account the unfavorable soil and the dimensions of the ground system, the results were pronounced extremely gratifying. The dielectric losses, however, proved excessive and further curtailment of this loss was sought. The masts and guy insulators were held responsible for a major portion of these losses.

Subsequently an antenna resistance curve was obtained with the upright poles and guys grounded. A substantial reduction of dielectric wastage was thus achieved. Measurements were then made on one of the mast and guy systems used as an antenna, and excessive dielectric loss was evident. At this juncture, modifications were made in the insulating equipment; porcelain insulators displaced glass under the masts and a notable reduction in dielectric losses was vouchsafed when the nine porcelain egg insulators in the guys were displaced by three 24-inch porcelain rod insulators. Porcelain rod insulators were also used in the counterpoise and as the capacity was small, low dielectric wastage was effected—a feat attributed to these rolling-pin like insulators.

As a second chapter of the investigations inquiring into the reasons for the existence of comparatively high electrical resistances of radio antenna and ground equipment, the Radio Research Laboratory of the Navy Department installed a counterpoise for use in measurements. The design was insulated from the supporting stakes by 30-inch porcelain rod insulators, the counterpoise having a radius of approximately 55 feet and a height above the ground of three feet. Its capacity to the ground was 2,100 micro-microfarads. The measurements is determining the resistance gave surprising results; the minimum opposition of the antenna was 1.4 ohms, at 800 meters wavelength, and only 2.1 ohms at 2,000 meters. The ground and conductor resistance was 0.7 ohms. Employing the circular ground system, previously described, the corresponding value for ground and conductor resistance was 2.5 ohms.

"Considering the fact that the circular ground had a radius of 20 feet as against 55 feet for the radius of the counterpoise" (to quote Dr. J. M. Miller, radio aide of the Bureau of Steam Engineering of the United States Navy Department), "it is believed that a ground system of the same radius would not be greatly inferior to the counterpoise electrically, and very much better from a practical standpoint. It is hoped that there will be an oppor-

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tunity to try out the experiments on a larger scale. Everything favors proportionately low resistances as the size of the antenna and ground system is increased. The actual ground resistance should decrease nearly in proportion to the radius of the ground system. The resistance due to dielectric loss should also decrease rapidly as the capacity of the antenna increases."

Low electrical resistance in the functioning of shore-station antenna — the primary object of this investigation—is in the interest of increased efficiency in the radiation of electro-magnetic waves. At present power is supplied the antenna and a portion of the power is usefully consumed in the radiation of waves. The remainder of the power, however, is needlessly squandered in ground and dielectric resistances. The lower these useless losses are reduced the more efficient the antenna becomes. Then, too, when the radiation resistance is at a minimum it requires less current for an antenna of specified resistance to obtain a given efficiency. High-powered radio stations realize the importance of a reduction of electrical resistance. On board ships, the problem is that of a curtailment of dielectric losses rather than a search for efficient ground connections. The latter condition is ever present on seafaring vessels. There are three different resistance components in the functioning of an antenna; the true radiation resistance is the only useful one. The other two—ground resistance and dielectric losses—are useless. Efficiency demands that they be reduced to as low a value as possible.

The results of the experiments described conclude that if the current flow in the ground is not restricted a low resistance is effected. A counterpoise covers a comparatively wide area, has a high electrical capacity to ground, and there is no concentration of current; hence the resistance is low.

Another conclusion deduced by this investigation is that in the present ground systems much of the conductor planted

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The wires that radiate from the common center connection under the table form one plate of a large air condenser; the ground is the other plate.

in the soil is useless. There is a tendency for the current to flow off the ground wires through the soil. The ground connections employed in this experimental equipment hearkens back to a system originated by Capt. Round called the "round" ground. The metal plates are set on edge in a circle in the soil around the foot of the lead-in. The insulated conductors from the circular ground are brought out above the surface of the earth, and are joined together at the foot of the lead-in. The area is effectively used—the current flow over each square

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foot being about the same as every foot of buried conductor. To avoid dielectric losses the antenna was established at a considerable distance from trees and buildings. Insulators were used in both antenna and counterpoise. The symmetrical antenna with the ground system is most effectual for use with the "round" ground.

How well this experimental antenna has lent itself to the reduction of resistance—the remarkable accomplishment of 1.4 ohms at 800 meters wavelength with a small antenna—may be illustrated by the following comparisons: an extreme example is that of the portable military antenna, that has a resistance as high as 120 ohms. The average small good antenna has a resistance ranging from 6 to 8 ohms. Only the enormous high-power stations have succeeded in curtailing opposition to a minimum of 1 or 2 ohms.

How to Use Your Phonograph As a Loud Speaker

By FRED WOODWARD

AFTER one has been operating for a time a radiophone receiver equipped only with telephone receivers, one is overcome with the desire to possess a loud-speaking horn in order that he may entertain more people at one time with the music he receives from the broadcasting stations. Here is a way to hook up your radiophone to your phonograph and save yourself the expense of purchasing an amplifying horn:

From a photograph made for POPULAR RADIO

Take the reproducer off the tone-arm of the gramophone. In most talking machines this may be easily done by the removal of one small screw. This leaves two small holes at the end of the tone-arm. Then place the receiving ear piece over each of the holes at the end of the tone-arm, and fasten them in place with a stout rubber band.

Then throw on the aerial switch and tune-in for whatever you wish to receive—music, news or signals. You will be surprised with the result. The gramophone cabinet, as you know, is the sound-box of the machine. When you have hitched up the telephone receivers of your radiophone to the tone arm of the gramophone you will discover that the box does for the radiophone exactly what it does for the gramophone record and reproducer: it amplifies, or magnifies, every sound that it receives.

If your radiophone is in anything like working order the music will be easily heard all over the room. It will allow you to have your friends listen to incoming signals without the necessity of getting additional apparatus. It will amplify radiophone music to such a degree that it may even be used for dancing.

This trick cannot be done with a crystal receiving set. It is necessary to have at least a one or two-step audio frequency amplifier.

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THIS *department is conducted for the benefit of our readers who want expert help in unravelling the innumerable kinks that puzzle the amateur who installs and operates his own radio apparatus. If the mechanism of your equipment bothers you—if you believe that you are not getting the best results from it—ask* THE TECHNICAL EDITOR.

THE flood of inquiries that has poured in upon the Technical Editor has not only furnished evidence of the need of this department; it has also necessitated a system of handling the correspondence that will insure the selection of and answer to only those questions that are of the widest application and that are, consequently, of the greatest value to the greatest number of our readers. Our correspondents are, accordingly, asked to cooperate with us by observing the following requests:

1. Confine each letter of inquiry to one specific subject.
2. Enclose a stamped and self-addressed envelope with your inquiry.
3. Do *not* ask how far your radio set should receive. To answer this inquiry properly involves a far more intimate knowledge of conditions than it is possible to incorporate in your letter.

The questions that are not of sufficient general interest to warrant publication in this department will be answered personally. Many of these questions are being answered by referring the correspondents to items that have already been printed in these pages. To get the full benefit of this service, therefore, *save your copies of* POPULAR RADIO.

QUESTION: I would like to put up a radio set of my own, but there are no poles or trees near my home. Can I put up the antenna from the fire escape to the other window? The length of the antenna would then be about 15 feet. Would I then be able to hear distinctly? Is lead-in wire the same as copper wire No. 14 insulated or bare?

L. A. W.

ANSWER: The antenna you suggest would be far too short. You should have at least one wire 100 feet long for the best results. You will hear signals weakly at best with the 15 foot antenna. The lead-in wire may be No. 14 copper either insulated or bare. If bare wire is used for the lead-in, it should be mounted on insulators.

* * *

QUESTION: Will you tell me how to eliminate the noise in a 2-step audio frequency amplifier that works all right otherwise? I am using the hook-up advised by the makers of Radiotron tubes and am using these tubes throughout, with a Radio Corporation transformer in the first step and a Federal transformer in the second step. Common 45-volt "B" battery is used for detector and amplifier with suitable taps. All wiring is bus bar type, soldered and insulated, with minimum parallelism. Transformers are placed between the tubes. Will a storage "B" battery eliminate the trouble? I am using a second Edison 6-volt storage battery for the "A" battery. Please give me a detailed hook-up to show all the apparatus necessary for one or more steps of radio frequency amplification.

W. R. PARTINGTON

ANSWER: One suggestion that may help is to ground the cores of the amplifying transformers. Another precaution against noises is to ground the negative terminal of the "B" battery. If the cells of the "B" battery get old they sometimes make "frying" noises. I recommend that you try the hook-up given in our June issue in this department. The storage "B" battery will not eliminate the noises unless your present "B" battery is the cause of the trouble, which could then be remedied just as well by replacement with new "B" batteries. In reply to your last request I am glad to refer you to an excellent

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article on radio frequency amplification to be published in a near issue of this magazine.

* * *

QUESTION: Will you send me a diagram for making up a set for receiving up to 1,500 meters? What would be the cost of such a set?

HANS J. POLL

ANSWER: In the May issue of this magazine (page 59) is given a hookup suitable for the purpose you desire. You should substitute for the three coils there given the three following coils which will give you the wavelengths you desire: Primary L-150, Secondary L-200, Tickler L-250.

* * *

QUESTION: I want to get a hook-up of a circuit for using crystal and audion detectors by merely throwing the switch. Can you give me one?

S. V. FINLY

ANSWER: You do not say whether you want to use this hookup with a single circuit tuner or a double circuit tuner. However, here is a circuit for a double circuit tuner, (Fig. 1) as this is the most efficient for tuning purposes. A single pole, double throw switch, will be required as shown connected in the diagram. To use the audion throw the switch to "A" and turn on the filament. To use the crystal detector throw the switch to "D" and turn off the filament of the audion and adjust the fine wire on the crystal detector.

QUESTION: My receiving set works all right, while I am sitting absolutely still, but if I so much as turn my head or move my arm or lean forward or backward, I hear crackling noises that nearly break my ear drums. I am using a Paragon receiver and two stage amplifier with Baldwin fones. Aside from this peculiarity the set works well and I listen to Pittsburgh, Schenectady, Detroit, and a number of other long distance broadcasting stations. Can you offer any suggestions for a remedy?

GEO. B. HILL

ANSWER: The symptoms you have given indicate that the telephone cords are worn through and when you move your body the cords also move and the fine stranded wires make and break the connection, thus causing the series of clicks and crackling noises that bother you so much. Purchase a new set of telephone cords and replace the old ones on the headset and your troubles will be ended.

* * *

QUESTION: Please tell me what a good audion set will cost that will receive over a distance of 200 miles?

A. W. ROSE

ANSWER: This set should include a detector and two-stage amplifier of the vacuum tube type. It will cost slightly over $200.00 complete.

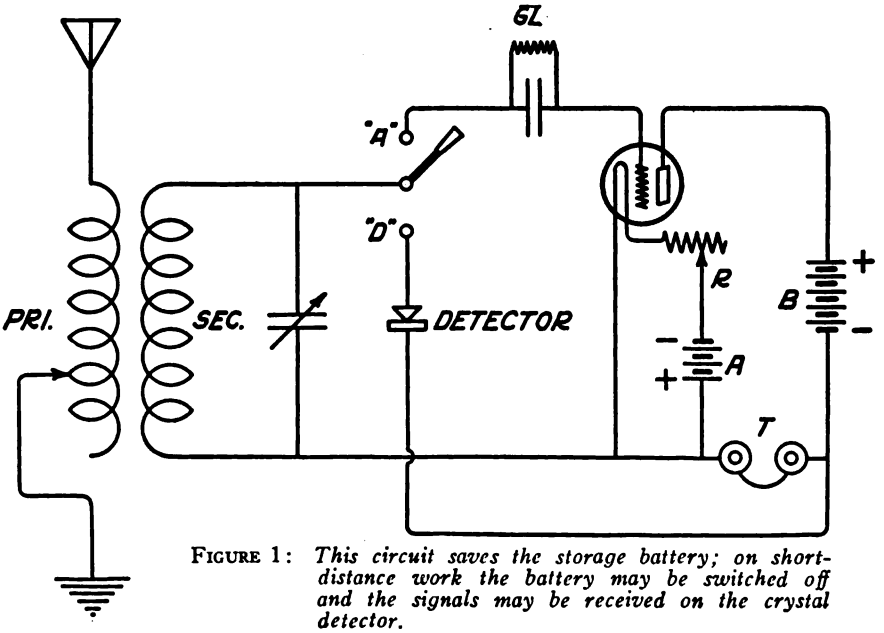

FIGURE 1: *This circuit saves the storage battery; on short-distance work the battery may be switched off and the signals may be received on the crystal detector.*

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QUESTION: How far can I receive on a crystal detector and a slide coil? I have just put up a one wire aerial 150 feet long and 35 feet high. The aerial has a little slant; does that matter?

ALBERT MUNN

ANSWER: A slight slant will change the electrical characteristics of the antenna a little, but it will not interfere with the strength of your signals. You should be able to receive up to a distance of twenty-five miles from the broadcasting stations.

* * *

QUESTION: A friend of mine who lives in the apartment below mine has become so interested in my receiving set that he has asked me to get him the necessary apparatus and help him to rig it up. I agreed to do so. Will I have to put up another aerial, or can we both use the same one?

A. PAGE

ANSWER: You will not get good results on either set if you connect both sets on to the same antenna. One set would absorb most of the energy and the other would get little, in accordance with the wavelengths that both sets may be tuned to. If both sets were to be tuned to exactly the same wavelength they would divide the current between them but signals of only half strength would be received by both. Use separate antennæ.

* * *

QUESTION: Is there any way to keep a crystal detector set in adjustment? I have trouble when I try to get it set because when there are no signals coming in I do not know whether it is in adjustment or not.

ANSWER: You should build a buzzer test for this purpose. The instruments you will need for this are the following:

1. A buzzer such as is used for code practice.
2. A dry battery.
3. A push button switch.
4. A few feet of wire.

Connect these up, as shown in Figure 2, with one wire running over and connected to the ground lead of your receiving set. When you want to adjust the detector, press the button and adjust the contact on the detector until the sound of the buzzer is heard loudest in the telephones; then the detector will be in adjustment and you can tune around with the tuning instruments; if there are any stations transmitting at the time you will hear them. The buzzer acts as a miniature transmitting set.

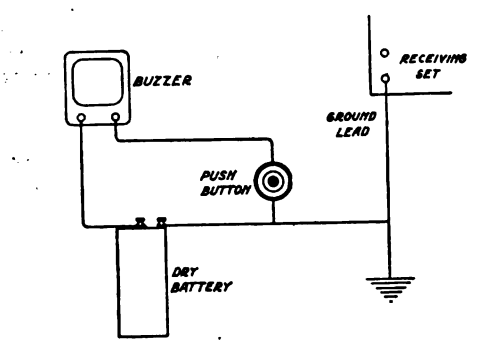

FIGURE 2: *A buzzer test for a crystal detector.*

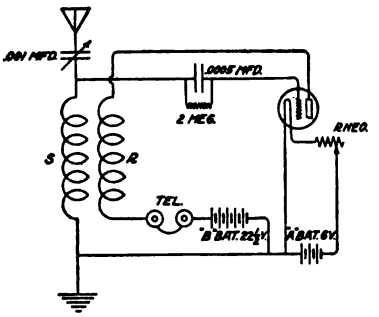

FIGURE 3: *A Hook-up for a single circuit regenerative receiver.*

* * *

QUESTION: Will you give me a hook-up for a single circuit regenerative receiver that employs an audion detector?

W. S. MITCHELL

ANSWER: The circuit described uses a variometer in which the stator has been disconnected from the rotor and the rotor placed in the plate circuit. A .001 mfd. condenser in series with the stator comprise the tuning elements. All tuning is done by revolving the variable condenser knob. The regeneration is accomplished by revolving the rotor of the variometer. (See Figure 3.)

* * *

QUESTION: What is the best kind of wire to use for an antenna?

D. W. JACKSON

ANSWER: The most efficient wire to use for an antenna is a copper wire with an enamel coating. The high frequency radio currents induced in an antenna travel on the surface of the wire. Ordinary copper wire oxidizes when strung up out in the weather, and the oxidization offers resistance to these currents. The enamel coating prevents the wire from becoming oxidized.

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QUESTION: Where can I get a wireless directory that gives all the calls of wireless stations, amateur, Government and commercial, which do transmitting in the United States. B. W. WHEELER

ANSWER: Send 15 cents to the Government Printing Office and ask for a copy of the yearly "Amateur Radio Stations of the U. S."

* * *

QUESTION: What is a loading coil used for? Will it help me to receive from greater distances than I now can get?

E. B. GINN

ANSWER: A loading coil is used in series with a radio circuit to increase the wavelength range of the set. It will not, however, increase the distance range from which you can receive.

* * *

QUESTION: I am using a well-known type of regenerative receiving set, but it howls and squeaks most distractingly. Is the set poorly designed or do you think that there is some connection loose?

L. J. H.

ANSWER: Most of the receivers on the market are of fairly good design and workmanship, and the trouble probably may be found in the way you tune it. You probably use too much regeneration while tuning; this causes a howling that may cover the whole scale of sounds from a shrill whistle to a low grunt. While tuning in a station, place the dial which controls the regeneration at zero; when you have the signals tuned in, slowly increase the regeneration until the signals are made strong enough without being distorted.

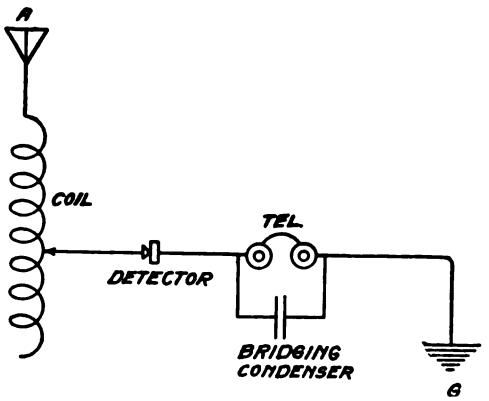

FIGURE 4: *A simple circuit for a crystal detector.*

QUESTION: I want to build a simple crystal receiver. The simplest circuit you could give me would be the best, as this will be my first attempt at building a set.

JOS. KENYON

ANSWER: The circuit shown in Figure 4 provides for a single slide tuning coil, a crystal detector, a small fixed bridging condenser, and a pair of receiving telephones. By adjusting the detector and moving the slider on the coil, different wavelength signals can be picked up. The range of this set is about 20 miles.

* * *

QUESTION: What is the best detector to use in a radio receiver?

WM. HANSEN

ANSWER: The vacuum tube or audion is by far the most efficient. The crystal detector is cheaper and simpler to operate, but it will not detect distant messages or bring in signals as loud as the audion.

* * *

QUESTION: What is the correct length of antenna to use in order to receive the radio broadcasting on 360 meters? My antenna is only 40 feet above the ground.

F. G. ORNEROD

ANSWER: You should make your one wire antenna about 100 to 150 feet in length. Use as short a lead-in as possible.

* * *

QUESTION: I have a quantity of fixture wire which I can strip of its rubber and braided covering, if it would be of any use. Will this wire be suitable or not? I do not want to do all this work only to find out that the wire is no good for such a purpose.

H. BARNES

ANSWER: You may use the wire but you do not have to strip it of its insulated covering as it will work just as well with it as without it. The insulation does not affect the antenna in the least as far as functioning efficiently is concerned.

* * *

QUESTION: What is the difference between a variable condenser and a variometer?

L. L. ROMERSHEUSER

ANSWER: A variable condenser is an electrical instrument for controlling the amount of capacity in a circuit. A variometer is an electrical instrument for controlling the amount of inductance in a circuit.

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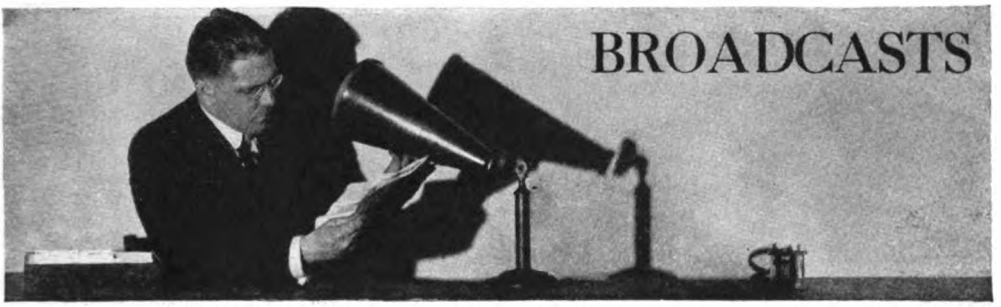

ITEMS *of general interest that you ought to know; bits of information of practical usefulness to every radio amateur.*

There Are Now 253 Broadcasting Stations

FIGURES obtained from the Department of Commerce show that there are 253 broadcasting stations now licensed and in operation. Most of these stations are concentrated either north of the Mason-Dixon line and west of the Mississippi or on the Pacific Coast. There are practically no stations as yet in that part of the west that lies just east of the Rockies. The installation of stations has only just begun in the South.

John Bull Begins to Take an Interest in Radio

PLANS are at last being made over in England to develop radio on a large scale —but along different lines from the recent expansion in America. Up to this time the Post Office Department has made the use of radio apparatus by private persons almost impossible, owing to the licensing system which applied both to receiving sets and to sending apparatus.

Now, however, steps are being taken to change this policy and to permit the extension of radio telephony.

As soon as restrictions are removed it is understood that the Marconi Company will establish a large transmitting station, and that receiving apparatus will be hired out at a charge which will probably not be more than that of the ordinary telephone installation. It is reported that the Marconi concern is ready to make innumerable fool-proof instruments that will be rented out.

English newspapers are only just beginning to explain to their readers the general features of radio telephony.

Radio Messages Received While the Operator Is Absent

A RADIO relay recorder that receives and copies messages without the use of a trained radio operator, operates mechanism automatically in accordance with the signal received and acts as an automatic call system has been perfected by F. W. Dunmore of the radio laboratory of the Bureau of Standards. It is sensitive enough to convert accurately feeble radio signals into records, yet will operate in a vibrating airplane.

"The practical operation of relays actuated by received radio signals is a comparatively recent development, and has been made possible by the development of the electron tube amplifier," says Mr. Dunmore. "The relay recorder is designed to operate from the output terminals of a radio receiving set; it may also be operated by any other source of audio-frequency signal. By the use of special electron tube circuits the audio-frequency signal is caused to operate an ordinary telegraph relay. In order to avoid the necessity for using a sensitive relay, designed to operate on currents of a milli-

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THE STATE CONSTABULARY IS EXPERIMENTING WITH RADIO

Every evening at about 8.50 o'clock the Boston police reports are broadcasted from the station at Medford, Mass. This picture shows how these reports are checked at headquarters of Troop A of the Massachusetts State Constabulary forces at Framingham. Experiments are being made there with radio equipment on motorcycles.

ampere or less (which would have delicate adjustments and light contacts and spring tension), advantage was taken of a vacuum tube to increase the input voltage to the relay circuit, thus making possible the use of a simple ordinary high-resistance telegraph relay. The relay device has therefore been developed to operate from the output circuit of any suitable amplifier in place of the ordinary phones."

The operation of the relay may serve to work a sounder, buzzer, tape register or any mechanism for remote control by radio. By the use of two of these relay recorders connected in series, two messages sent on practically the same wavelength but of different audio-frequencies are caught at the same time and recorded in the operator's absence.

Broadcasting Stations Must Not Interfere With Each Other

"BROADCASTING stations should shut off transmitters when they are not in actual operation in order to prevent unnecessary interference from carrier wave," says an official warning from the Bureau of Navigation of the Department of Commerce.

Sending stations are also asked not to interfere with the schedules of other stations; transmitters must be adjusted so as not to produce unnecessary interference. The Bureau has found that some broadcasting stations have interfered over a band from 200 to 500 meters, which hereafter may be reported as a violation of the law, with the subsequent imposition of a penalty.

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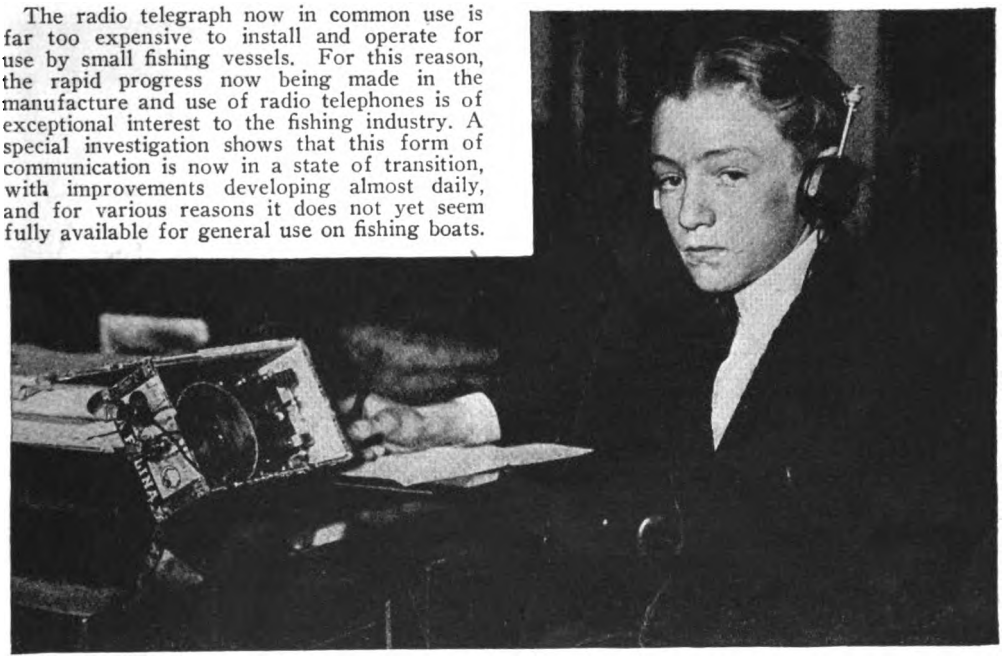
The Radiophone to Replace Carrier Pigeons

ONE of the impending applications of the radiophone is in the tuna fishing industry, which has been employing carrier pigeons in keeping the boats of the fishing fleet in occasional and uncertain communication with the canneries on the Pacific coast. The fishing vessels set forth on their tuna hunting expeditions early in the season in the waters near Coronado Islands, off San Diego, as the schools of tuna move northward the boats follow. While the fishermen keep more or less in touch with the home ports through the craft which carry back the catches, they have depended largely upon birds, which at best constituted a one-way service. The *Pacific Fisherman* thus points out the possible uses of the radio in developing the tuna fishing industry:

> The radio telegraph now in common use is far too expensive to install and operate for use by small fishing vessels. For this reason, the rapid progress now being made in the manufacture and use of radio telephones is of exceptional interest to the fishing industry. A special investigation shows that this form of communication is now in a state of transition, with improvements developing almost daily, and for various reasons it does not yet seem fully available for general use on fishing boats. In certain cases, however, it might be exceedingly useful, even at the present stage. The transmission of messages is still a complicated matter, requiring the services of an expert; but receiving instruments are available at very reasonable prices, and are easily used, and the broadcasting service is expanding daily. For sending instructions from a central station to cannery tenders and trap watchmen, this equipment might be found of great value; and a few broadcasting stations in Alaska, sending out market quotations on halibut and salmon, in addition to the usual news and entertainment features, should be an exceedingly popular feature with the fishermen.

Is There to Be no Escape from the Collection Plate?

EVEN the passing of the collection plate has become a reality in the church service conducted by radio. So many listeners enjoyed a recent sermon broadcasted from the WJZ station by the Rev. Edgar S. Wiers, pastor of a church in Montclair, N. J., that they sent in by mail their money for the heathen.



International

MUSIC FROM AN OLD CIGAR BOX

Make a wireless set for receiving with only a cigar box, parts of an old typewriter, a piece of an oatmeal box, a few clips off Christmas tree candle holders, and a piece of galena? That is exactly what Herbert Parish, sixteen years old, constructed in less than a half hour, in order to hear the broadcasting of music by radio. The set is said to work satisfactorily over short distances. Any ingenious lad who is handy with tools can do the same.

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A Home-Made Radio Set That Received 300 Miles

The remarkable accomplishment of the crystal receiver described in the May issue of this magazine. The ordinary range of such an equipment is only twenty-five miles. The figure below shows the installation.

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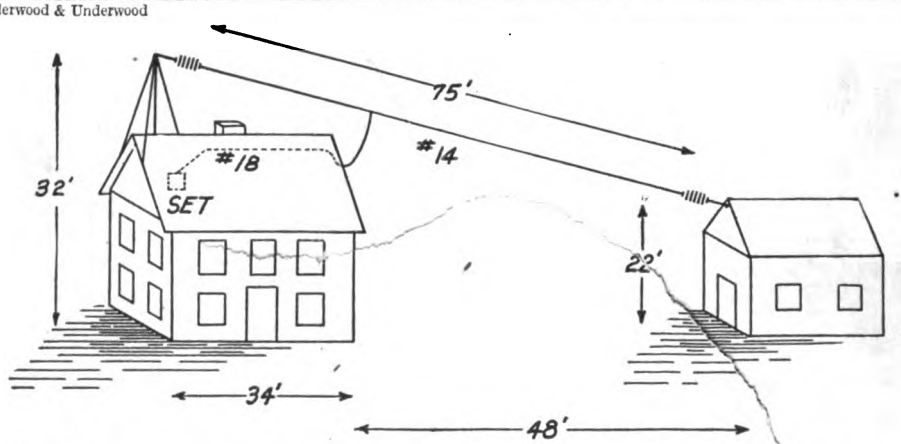

THAT the home-made crystal receiving set as evolved by the Bureau of Standards and described in detail in the May issue of POPULAR RADIO is a thoroughly practical instrument has been demonstrated by the letters which have come to the Editor. Here, for example, is what J. O. Hodge, of Washington, D. C., heard on the small set which he built himself out of material that cost him about $11.00:

Radio concerts in Schenectady, three hundred miles away, have been heard plainly on the crystal receiving set in Washington, D. C., and the Pittsburgh broadcasting program, coming from over the Alleghany Mountains, has been picked up and followed without difficulty. The set was the simple arrangement recently designed and described by the Bureau of Standards. The crystal and head-set, which was the metal diaphram type, were purchased in an ordinary supply store.

Similar results can be attained by anyone under favorable conditions. Indeed, this performance should be duplicated wherever there is a good open space for erecting an antenna. In this case the aerial consisted of a single No. 14 wire 75 feet long, 31 feet high at one end and 22 feet high at the other; it was strung between two frame houses in a neighborhood that was free from steel structures and metal framing of any sort, as shown in Figure 1. The set was

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mounted in a room on the upper floor below the high end of the aerial, but the connection was made by a No. 18 bell wire which ran along the ceiling of the rooms of the upper floor and was connected to the aerial after it had passed over the house about a third of the distance from the high end.

Fading was, of course, noted; that is, the strength of the signals sometimes increased and decreased for periods of 10 or 20 seconds, depending upon atmospheric conditions; this will be the case with any receiving set. Now and then the signal disappeared altogether for a few seconds. However, this was not serious, as whole concert numbers lasting five minutes or so were often received clearly and without interruptions.

C. A. Briggs.

An Electron Tube Radio Receiver Without a Storage Battery

A RADIO receiving apparatus that uses ordinary electron tubes for amplification but which does not require a storage battery has been developed by the radio experts of the Bureau of Standards.

The current to light the filaments of the electron tubes is obtained from an ordinary electric lamp socket instead of from the storage battery which the experts characterize as "a drawback to the general use of radio sets and the most expensive portion of the equipment for the person who wishes to make his own set."

How to use the electric light wires themselves as an antenna and thus eliminate entirely the need of erecting an antenna has also been worked out by the government radio engineeers in connection with this new set, although the signals are likely to come in with less

© Ewing Galloway

A SET THAT RECEIVED HALFWAY AROUND THE EARTH

That the radio equipment on the ocean lines "Vauban" is one of the best adjusted on the high seas was recently demonstrated when Chief Wireless Operator F. W. Walsh picked up a message from the Philippines while the vessel was on its way from Buenos Aires to New York—a distance of 11,500 *miles.*

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Kadel & Herbert

WHERE THE RADIO FAN MEETS THE BASEBALL FAN

A New York boy recently entertained the younger element in his neighborhood by bringing his receiving set down on the street below his apartment and posting the scores of the games as they were announced by radio. In between times his audience were entertained by music from the loud speaker.

strength when this is done. The new design of receiving set can be used, however, with any type of antenna.

"The new receiving set consists essentially of an amplifier with minor auxiliary parts," the experts explain. "The amplifier utilizes 60-cycle current supply for both filaments and plates of the electron tubes. This amplifier has three radio-frequency stages and two audio-frequency stages, and uses a crystal detector. The 60-cycle current when used in an ordinary amplifier circuit introduces a strong 60-cycle note which offers serious interference. This has been practically eliminated by balancing resistances, grid condensers and special grid leaks of comparatively low resistance, a telephone transformer in the output circuit, and a crystal detector, instead of electron tube detector. In the final form of the amplifier, there is only a slight residual hum which is not objectionable. The amplification obtained with A. C. supply was as good as that obtained with the same amplifier used with D. C. supply. The complete unit is light, compact and portable. For the reception of damped waves, the amplifier as constructed operated most satisfactorily for wavelengths from 200 to 750 meters; this range was determined by the working range of the radio-frequency transformers used. By using suitable radio-frequency transformers, it is expected that the amplifier will be effective for the reception of damped waves and undamped waves as long as 10,000 meters. For the reception of undamped waves, a separate heterodyne should be employed."

JIMMY—"You take this wireless receiver I just finished makin', and go downstairs in the cellar; hold it close to your ear and listen."

FREDDY—(*After waiting in suspense for several moments in the cellar*), "Aw—it's a fake, I didn't hear a thing."

JIMMY—"Good! That shows it's workin' right. I didn't say anything yet."

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HUTCHISON RADIO COMPANY

52 Vanderbilt Avenue, New York City

Dr. Miller Reese Hutchison, President.

(Formerly Chief Engineer Thomas A. Edison Interests)

BUSINESS: Manufacturing, assembling, marketing "Hutchison" Radio apparatus. Commercialization of non-infringing Radio inventions, accessories, parts, specialties; and merchandising products of other manufacturers.

MANAGEMENT: Well-known commercial, financial and technical group with long records of business success.

PRODUCTS: Non-infringing vacuum tube and crystal detector sets of advanced type; transmitting and receiving sets, wireless specialties and parts.

POLICY: Hutchison policy proposes rapid extension to annual production of 150,000 receiving and transmitting sets of varying sizes and prices.

The name "Hutchison" is well-known in the scientific and commercial world, and "Hutchison" quality wireless apparatus will be nationally advertised.

Dealers, Jobbers, Manufacturers and Investors Correspondence Invited

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52 Vanderbilt Ave., New York

Please send me information on "Hutchison".

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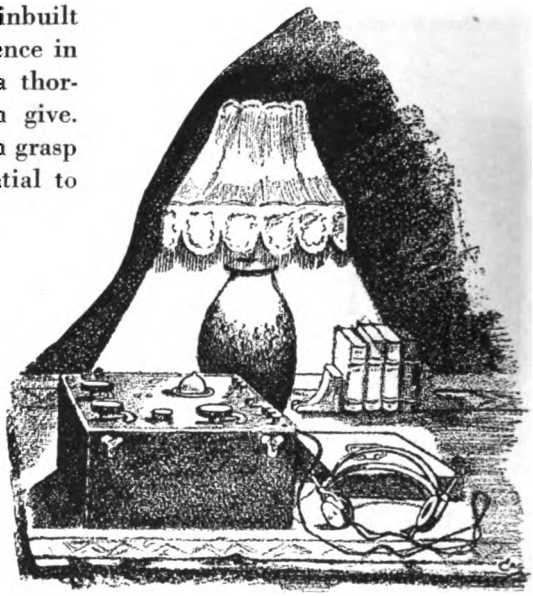
DE FOREST Dependability is an inbuilt quality that only years of experience in the building of radio apparatus and a thorough knowledge of radio science can give. It is not a tangible element that one can grasp or point out, yet its presence is essential to satisfactory performance.

To those who are looking for satisfactory performance, De Forest Radiophones also present technically correct design, handsome appearance and unequalled efficiency.

The Everyman Receiver is for 30 mile reception; the Radio-home Receiver is a vacuum tube set efficient up to 100 miles; for use with either of these sets there is the "DT-800" Two-Stage Amplifier. MR-6 Receiver includes an unsurpassed tuner, tube detector and two-stages of amplification. Ask your friends who use them.



De Forest Radiophones

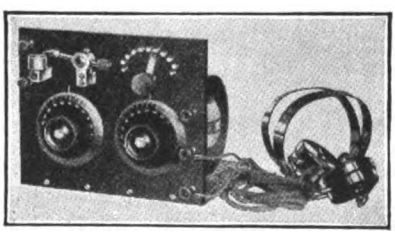
"The Standard of Dependability"

DUCK'S NEW CATALOG No. 16 *256 Pages. A Catalog De luxe*

"Over fifty pages of the latest hook-ups [wiring diagrams], and invaluable and up-to-date data and information on radio, including important instructions for building antenna."

Type CV Crystal Receiving Set $20.50

Beyond doubt the most advanced type of crystal set on the market for the clear and efficient reception of radio speech and music and telephone reception. Wave length range 700



meters. Headset Extra. Murdock. We caution the public unfamiliar with radio to be careful about the cheap, inefficient and poorly constructed crystal sets that are beginning to flood the market. We are the oldest dealers in America selling complete everything in radio. Established 1908. In tests with this set the radio telephone station at Detroit (60 miles distant) was heard in Toledo with the greatest clearness and sweetness. Ideal set for persons residing within range of powerful radio stations in New York City, Springfield, Mass., Pittsburgh, Chicago and Detroit, where wonderful concerts are broadcasted every evening.

Our exclusive feature is the extra binding post for connection to our No. B 212 Detector Panel and B 214 2-step amplifier Panel, same height as panel on receiver. With this combination we have clearly heard radio concerts from all stations 500 miles from Toledo.

"Send 25c in coin carefully wrapped, for your copy of this wonderful book, the most unusual and complete catalog ever put between the pages of two covers. Not sent otherwise. It is not only a catalog, but a wonderful textbook on radio. Enormous cost and tremendous demand prevents further distribution at a less retainer."

Never in the history of radio has there been such a catalog.

The radio data and diagrams embracing upwards of fifty pages gives the experimenter more valuable and up-to-date information than will be found in many textbooks selling for $2.00, and $1.00 could be spent for a dozen different radio catalogs before you could gather together the comprehensive listing of worth while radio goods found in this great catalog.

A brief summary of the radio goods listed in this catalog:

The entire radio catalog of the Radio Corporation, with a wealth of scientific and technical data on C.W. transmitting sets, and all the diagrams for the assembling of these sets; the complete Remler line, which embraces 25 pages; the Westinghouse, Colin Kennedy, Murdock, Federal, DeForest, Western Electric, Brandes, Connecticut Company, Thordarson, Turney, Magnavox Company lines; the best products of Adams-Morgan, Signal and countless other manufacturers, including our own complete line of radio apparatus, and many individual items and parts used in radio work today.

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We want live, responsible dealers in every city and town in the United States, both for the sale of our extensive line of radio apparatus and all other worth while lines of radio goods, on all of which we can quote attractive dealers' discounts. We can offer you facilities and advantages that no other radio house can offer.

Send only 25c for copy of this wonderful catalog. You will need no other when you have Duck's and you cannot find in all others combined what you will find in Duck's Wonder Catalog.

THE WILLIAM B. DUCK CO., 227-229 Superior Street, Toledo, Ohio

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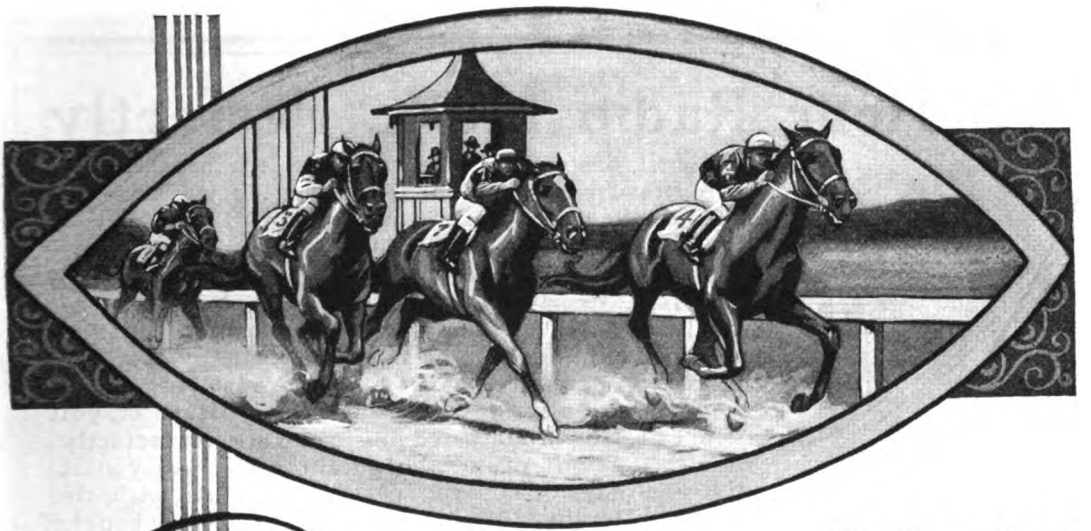

We're off !!!

MGC
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OFF the beaten path and on the trail to a worthwhile goal. "Thoroughbred Apparatus" has been constantly winning new friends and has hung up some enviable records as a quality leader in radio apparatus.

Our goal is *unwavering superiority,* and we intend to come under the wire *with* "Thoroughbred Apparatus" in the lead of the radio field.

On June 1st we moved into our new factory. Now, with greatly increased facilities, we are prepared to handle your orders as they come. Write for our interesting offer to reliable dealers.

"Thoroughbred Apparatus" consists of: Moulded Variometers, Vario-couplers, "Read 'em" Binding Posts, 17 styles, Amplifier Panels, Detector Panels, Variable Condensers, Fixed Condensers, Binding Posts, Contact Points and Stop Pins, Switch Levers, Dials, Single Sockets, Rheostats, Crystal Detectors.

THE MARSHALL-GERKEN COMPANY
Jackson & N. 12th Street, Toledo, Ohio

Thoroughbred Apparatus

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To Hear Radio Music Perfectly

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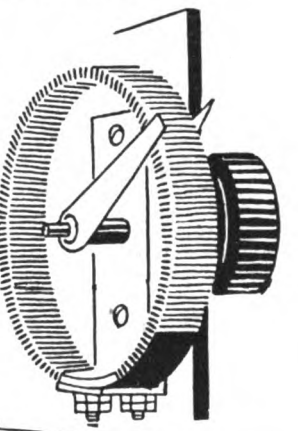

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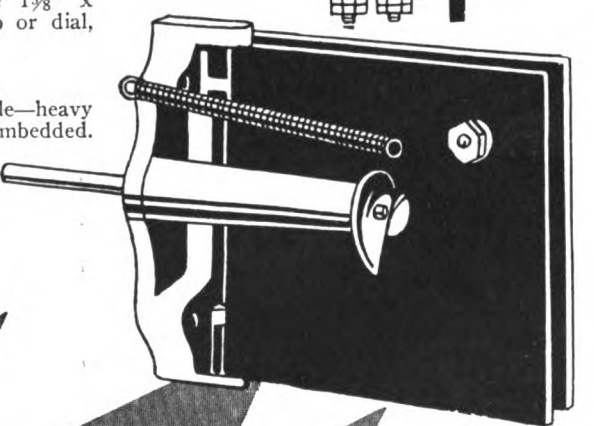

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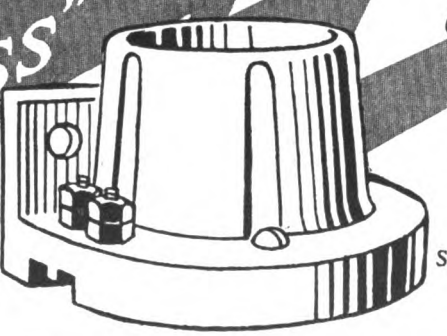

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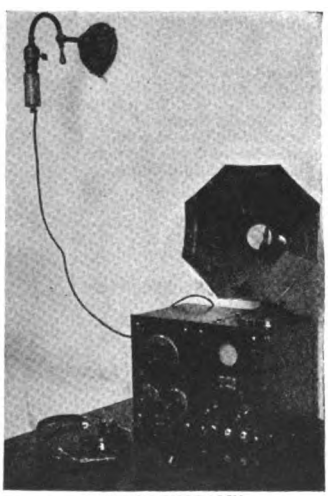

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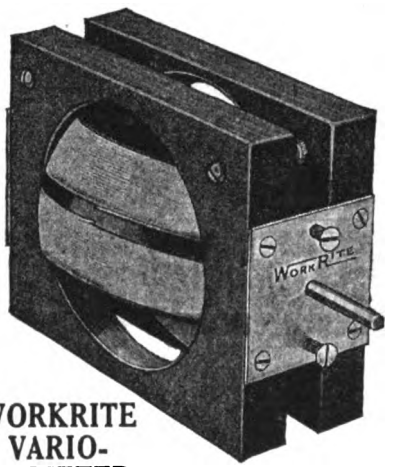

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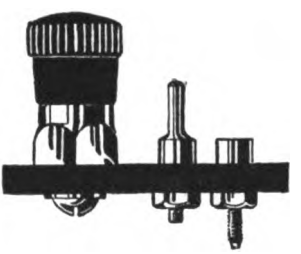

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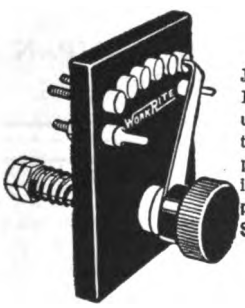

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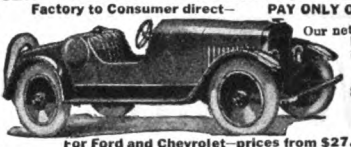

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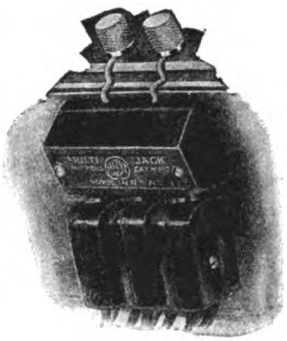

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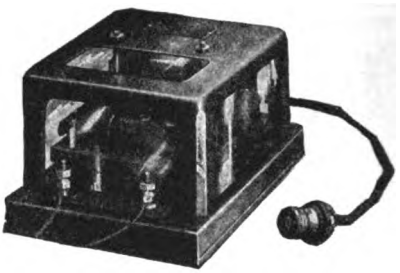

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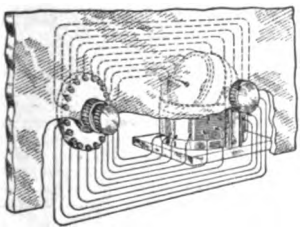
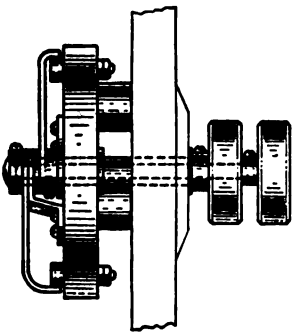


Installation with Variocoupler



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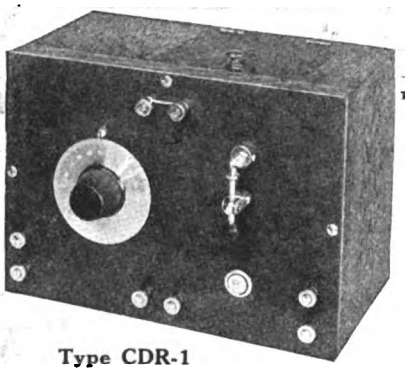

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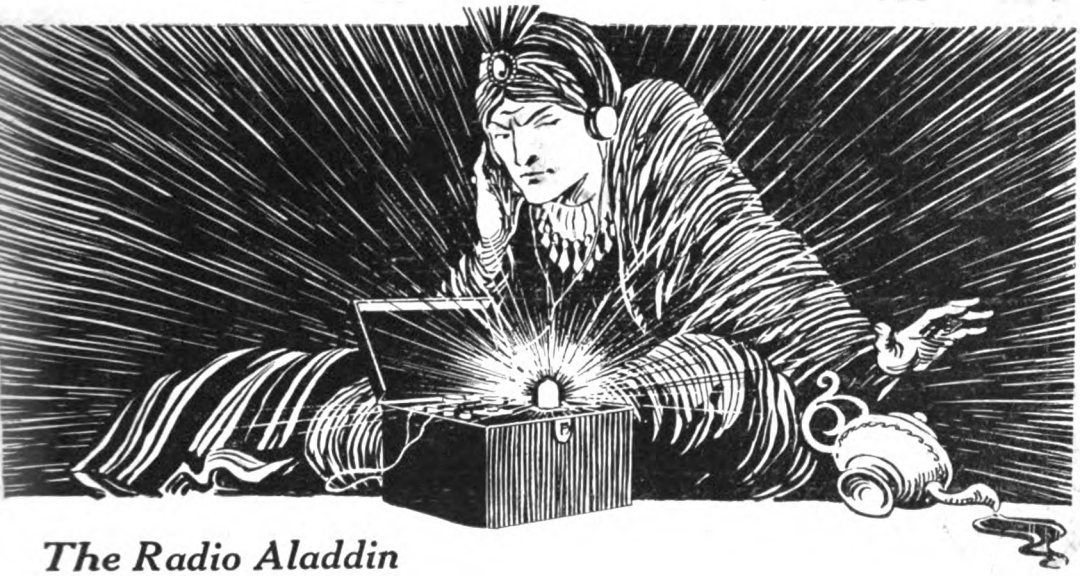

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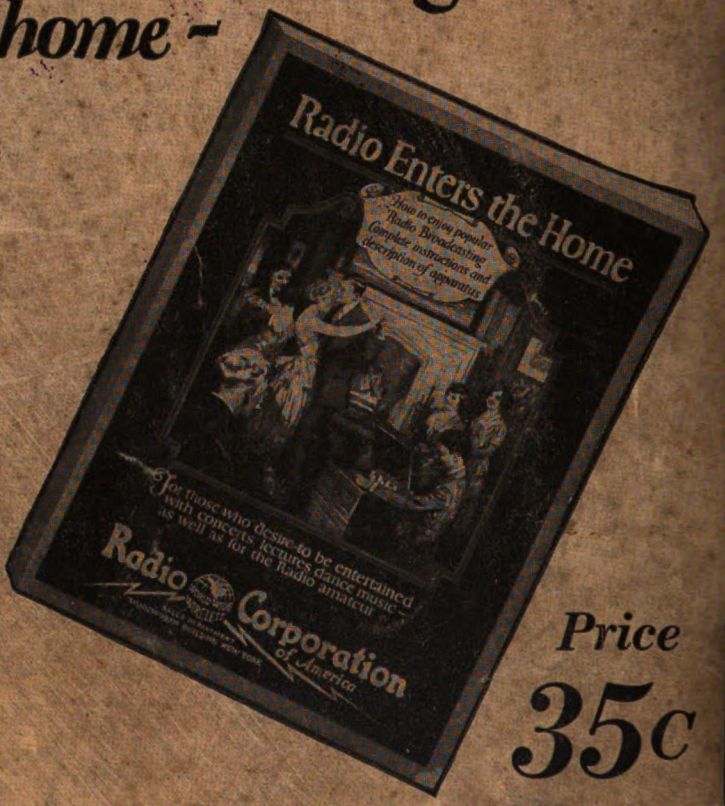

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Popular Radio

MAY 1923

THE JOHN CRERAR
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In this Number

How to Build the New Four-Circuit Tuner

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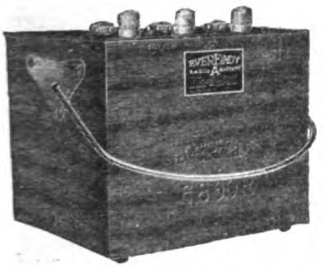

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POPULAR RADIO

EDITED *by* KENDALL BANNING

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E. E. FREE, Ph.D., *Contributing Editor* LAURENCE M. COCKADAY, R.E., *Technical Editor*

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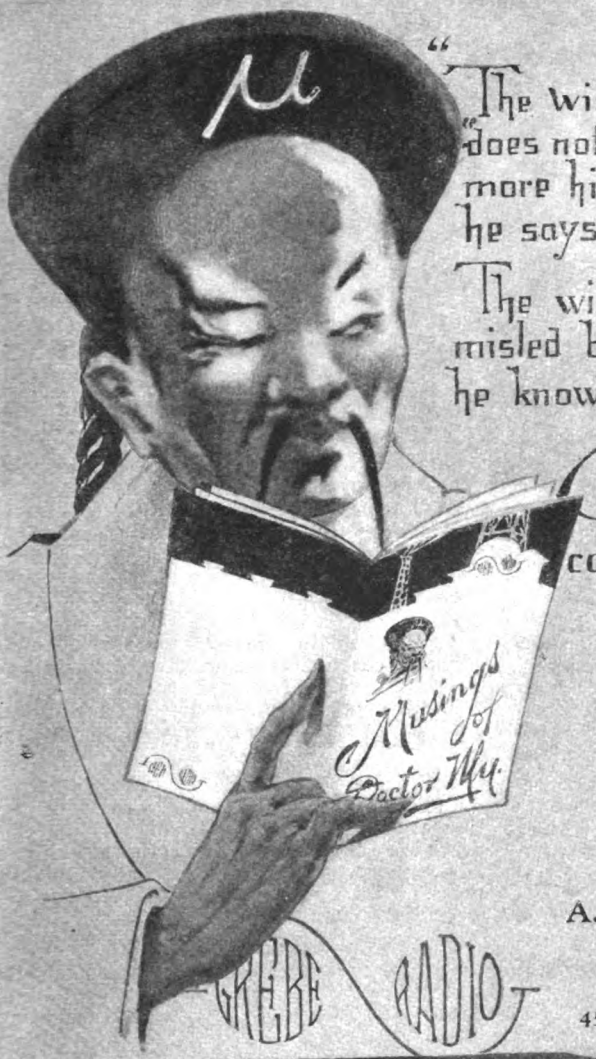

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A PAGE WITH THE EDITOR

EACH TECHNICAL QUESTION THAT WE ANSWER COSTS US 88 CENTS

Here is a picture of our Technical Editor, Laurence M. Cockaday (left) and his newest assistant, Albert G. Craig, studying some of the hundreds of inquiries that pour in from our subscribers. If YOUR *inquiry is somewhere in this pile, you will now understand why it is not answered by return mail.* BUT IT WILL BE ANSWERED!

WITH this issue POPULAR RADIO celebrates its first birthday.

* * *

DURING its eventful first year it has grown in bulk exactly 100 percent. Its advertising patronage has grown 785 percent. And its circulation has grown from nothing to somewhere about 100,000 copies a month—which represents a percentage so high that the Editor does not know exactly how to compute it!

* * *

GRATIFYING as is this remarkable evidence of material success—a success that has been made possible only by the friendly advice and co-operation of radio fans throughout the country—nevertheless the Editor is equally if not more concerned with the position of authority which POPULAR RADIO has attained in the world of science. How do the world's greatest scientists look upon us?

* * *

THE most conclusive answer may be found in POPULAR RADIO'S list of contributors—probably the most distinguished group of scientists ever assembled in any one magazine in so short a period. The list speaks for itself:

Sir Oliver Lodge, Guglielmo Marconi, Prof. James A. Fleming, Dr. Lee De Forest, General George O. Squier, Dr. Charles P. Steinmetz, Dr. Elihu Thomson, Dr. Henry Smith Williams, Prof. J. H. Morecroft, John V. L. Hogan, Paul Godley, Laurence M. Cockaday, Hudson Maxim, Dr. E. E. Free, Hiram P. Maxim, Nikola Tesla, Edwin H. Armstrong, Dr. Henry D. Hubbard, Dr. E. E. Slosson, Waldemar Kaempffert, John Hays Hammond, Jr.—to mention those that first come to mind.

And among its contributors of non-scientific articles are numbered authors whose names are known to magazine readers throughout the world.

* * *

To its rapidly growing number of subscribers, contributors and advertisers, whose essentially practical endorsement of the magazine has made its success possible, the Editor extends not merely thanks but congratulations.

* * *

AGAIN the flood of questions submitted to our Technical Editor by our readers is getting beyond control. Gratifying as this evidence is of the value of our Technical Editor's advice, nevertheless the accumulating mail is presenting a serious problem. How can the Technical Editor answer it all?

* * *

WE are answering *this* question in part by adding to our technical staff another radio expert, Mr. Albert G. Craig, with whom many of our readers are already acquainted. Mr. Craig graduated from Purdue University as an electrical engineer, and has had wide experience in important research laboratories. He is a member of the A. I. E. E., and a contributor to radio textbooks here and abroad.

* * *

Don't put aside your radio set just because summer is near! In the next issue we will tell you how to use your set on your vacation—and give you specific, practical information on the subject, together with actual hook-up diagrams and photographs of successful installations.

Kendall Banning

Editor, POPULAR RADIO

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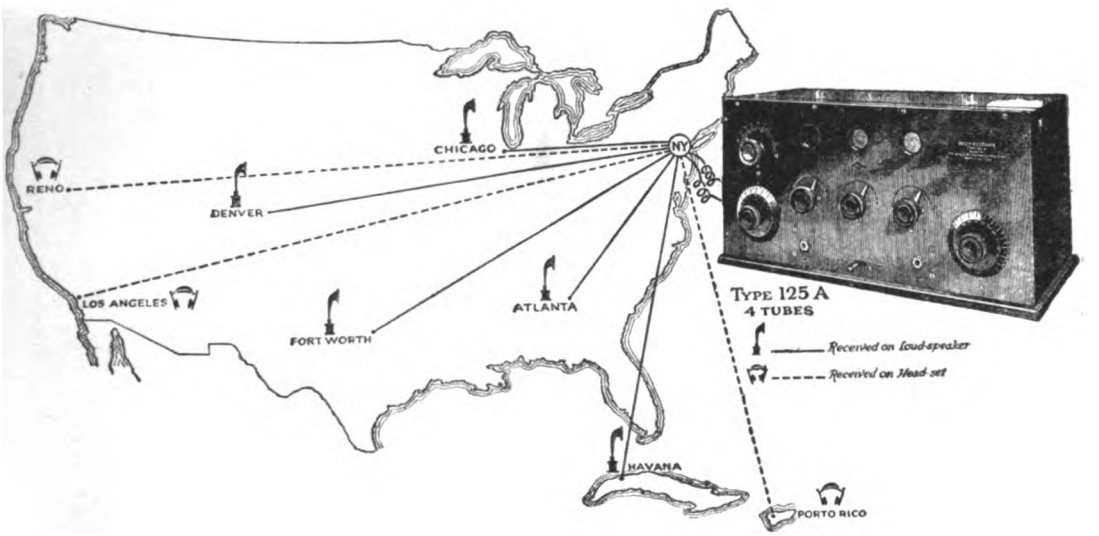

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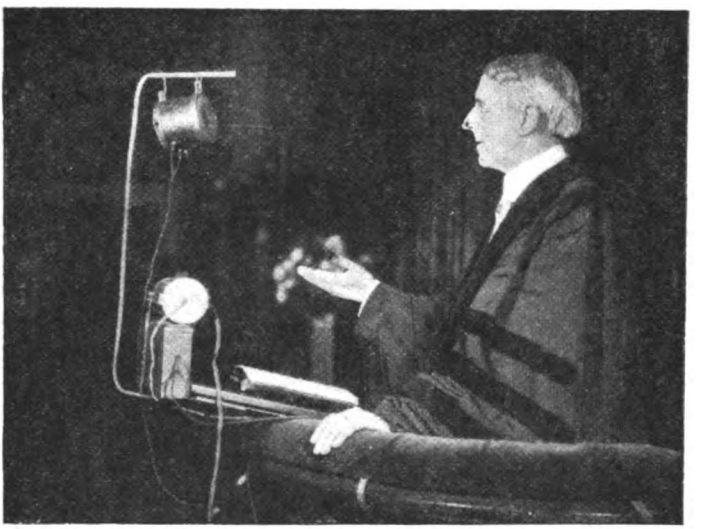

Underwood & Underwood

RADIO WILL HELP THE CHURCH

"THERE is, I know, a good deal of controversy as to just what effect radio is having or will have on church attendance. Judging from such letters as come to my desk from our invisible audience, I am led to believe that the effect will be favorable rather than unfavorable to church attendance."

A. Eaton Reynolds

PASTOR, WEST END CHURCH, NEW YORK

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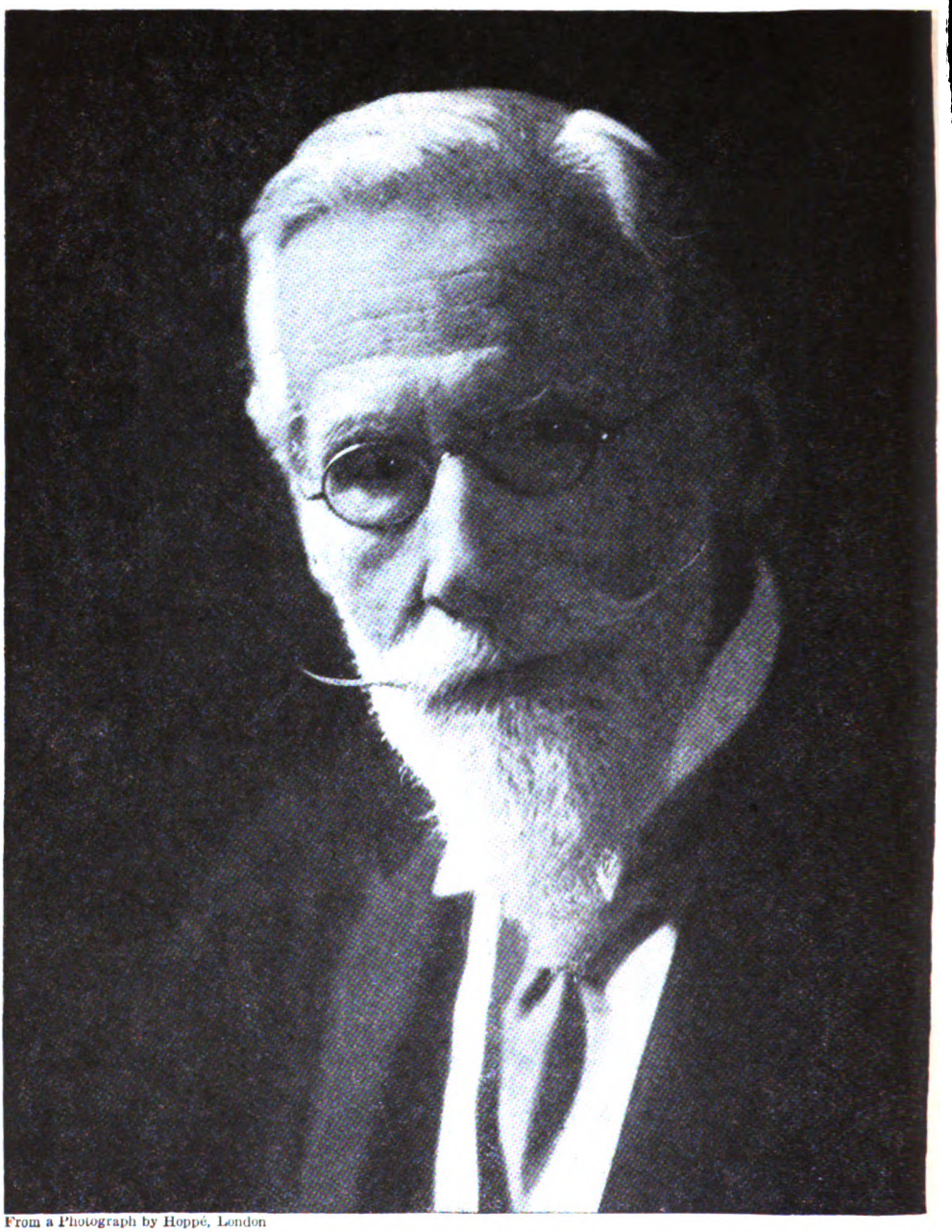

From a Photograph by Hoppé, London

The First Man to Create a Stream of Electrons in a Vacuum Tube

While Sir William Crookes *was experimenting with his own invention, the Crookes tube, in 1876 he noticed for the first time a glow discharge that "flew away from the cathode in radial lines." His investigations of this phenomenon led to the discovery of the X-ray by Roëntgen in 1895 and ultimately to the acceptance of the electron theory by scientists throughout the world.*

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Popular Radio

VOLUME III MAY, 1923 NUMBER 5

Thoughts *that* Shake the Ether

Radio signals never come to an end. Scientifically, they go on forever. So does every physical and mental impulse that we create. Ether makes us, in fact, immortal—as this article by a distinguished inventor points out with startling vividness.

By HUDSON MAXIM, DS.C., LL.D.

THE most marvelous and the most mysterious thing in the universe, so far as man can conceive it, is the ether. From the ether all the worlds have been quarried and from the ether all life has sprung. The commandeering of the ether in the radio service is a thing so wonderful and so masterful as to make the ghosts gaze.

If, in telephoning by wireless from New York to San Francisco, the voice should travel at merely the speed of sound, more than four hours would be required for the first word to reach the ear of the listener; whereas, by radio, the voice is transmitted at the speed of light, (186,000 miles a second) so that there is no appreciable lapse of time in the transmission of the voice to any distance on the earth's surface.

If, however, it were possible to establish radio communication with the nearest fixed star, *Alpha Centauri,* it would take four years, even by radio speech, to cross the gap. With merely the speed of sound, it would take four million years for speech to reach the Centaur.

If one of our amateurs should pick up a radio message sent out to us from some planet that is circling a sun on the far frontiers of the Milky Way, he would know that the sender of the message lived and died more than twenty-five thousand years ago, and that the message had been on the way all that time—and this, too, coming at the speed of light. For the light by which we see such a star left there 25,000 years ago, when the Cro-Magnons inhabited Europe, along with the saber-toothed tiger, the hairy mammoth, and the wooly rhino-

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ceros. From that time twenty thousand years had to pass before Egypt appeared on the far horizon of history. Babylon, Greece, Rome, also rose and fell during the five thousand years more before the message would reach the inhabitants of the earth, and also before the inhabitants of the earth would have the skill and knowledge to receive the message, and, perhaps, to translate it.

Time-honored sound is slow-paced compared with the speed of ether waves; still sound, too, has its marvels.

For example, on a quiet summer evening, one with keen ears can hear a katydid half a mile away. This means that that little insect, by rubbing its legs and wings together, is able to shake a cubic mile of air.

How much does a cubic mile of air weigh? Does it weigh a hundred pounds, a thousand pounds, or several tons? What do you think?

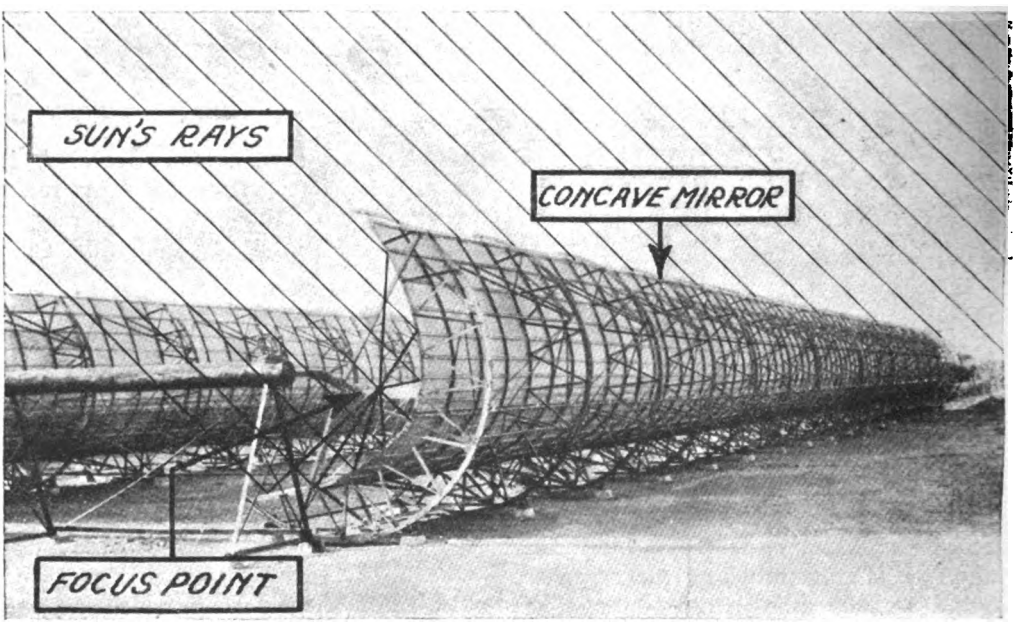
A cubic mile of air weighs more than six million tons—and that little katydid sets all that six million tons of air in rapid vibration!

A little chick-a-dee with its song thinks nothing of shaking up six million tons of air!

The ether about us is in a constant state of vibration of inconceivable intensity, but the ether of space fills up the gaps between the atoms of our body and so the vibrations pass through the space we occupy as freely as though it were a vacuum and, consequently, we are unconscious of the presence of them.

It would require a solid steel cable with a diameter equal to our earth, and having a tensile strength of 80,000 pounds to the square inch of cross section, to tether the earth to the sun, as the ether does by the force of gravitation.

Dr. Charles F. Brush, the great electrical inventor, of Cleveland, Ohio, has made some important discoveries upon the subject of gravitation. He has made some determinations, for example, which



Brown Bros.

HOW HEAT FROM THE SUN IS MADE TO RUN AN ENGINE

By means of these massive concave mirrors, the solar rays are concentrated upon a pipe that contains water; the heat thus obtained furnishes sufficient power to operate a low-compression engine. The "furnace" of its power plant is, in reality 96,000,000 miles away!

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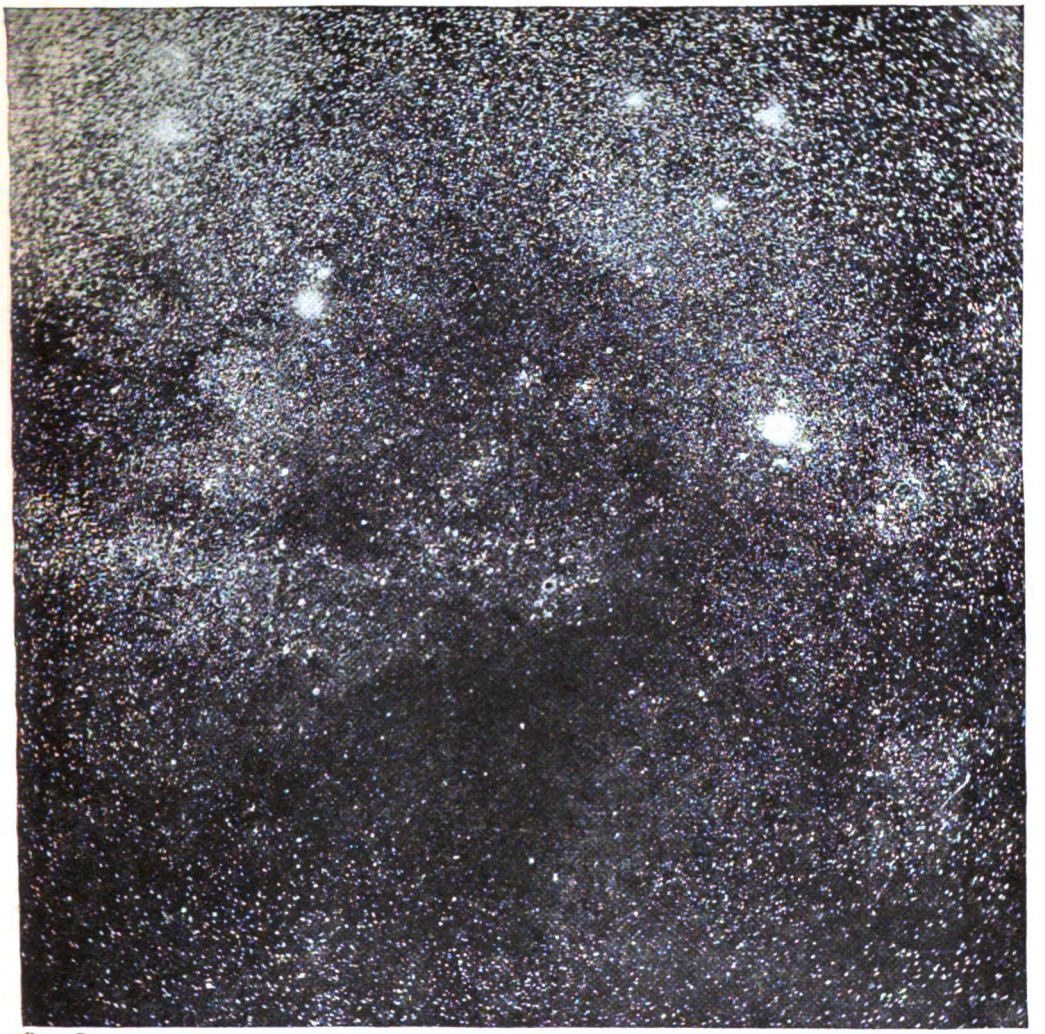

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WILL WE RECEIVE RADIO MESSAGES FROM DISTANT PLANETS?

Radio impulses travel at the same speed as light—186,000 miles a second. A signal sent to us from some planet on the frontiers of the Milky Way, to be recorded today, would have had to start on its journey twenty-three centuries before Christ!

are most convincing, *that gravitation is a push instead of a pull;* that the impingement of ether vibrations tends to push all masses of matter toward one another, because a body casts an ether shadow in proportion to its mass toward another body to which it is apparently attracted. He has also further determined that there is a difference between weight and mass of certain bodies, for the reason that all bodies do not resist the ether exactly according to their mass, with resultant proportionate gravitative force.

If gravitation is a push instead of a pull, then, when on the side of the earth away from the sun, we are under an ether pressure of forty tons to the square inch and do not know it.

The intense agitations of the ether do not interfere in the least with the transmission of our radio messages, for there is room down in the regions of the ultimate for many different agitations to

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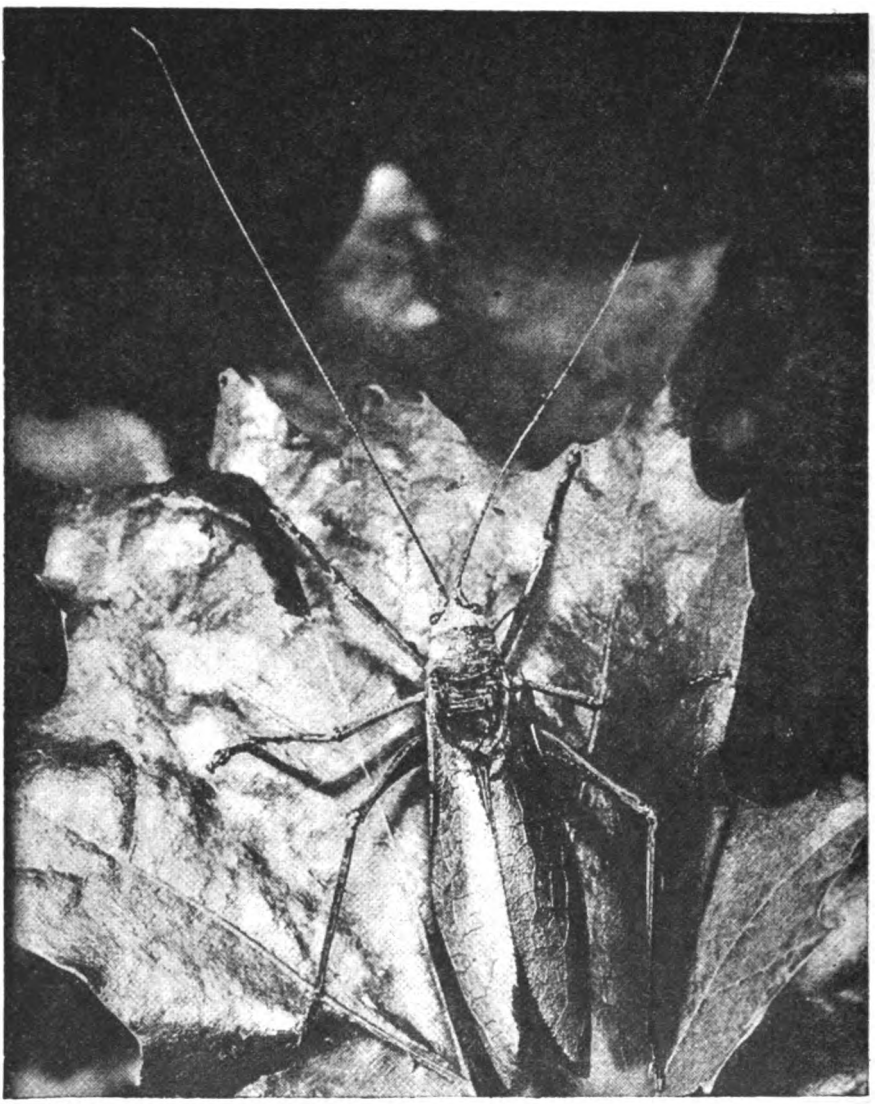

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ONE SMALL KATYDID CAN MOVE 6,000,000 TONS OF AIR

When this insect creates sound-waves that are audible half a mile away, he is setting in vibration a cubic mile of air. And air has weight that can be measured by means of the instruments of science.

abide together without interference. There are spaces which are relatively as enormous between things infinitely little as there are between the starry magnitudes of the heavens.

All of the suns in the universe have for all time been pouring their light and heat into space, which have been absorbed by the ether in the shape of vibrations which move onward and outward in all directions forever. Consequently, with time enough—and there has been time enough—the suns must of necessity have created an intensity of vibrations in the ether equal to that which exists on the face of a blazing sun. But all those vibrations do not exist as visual light and heat that can be sensed.

As a matter of fact, the latest discoveries in science indicate that not only

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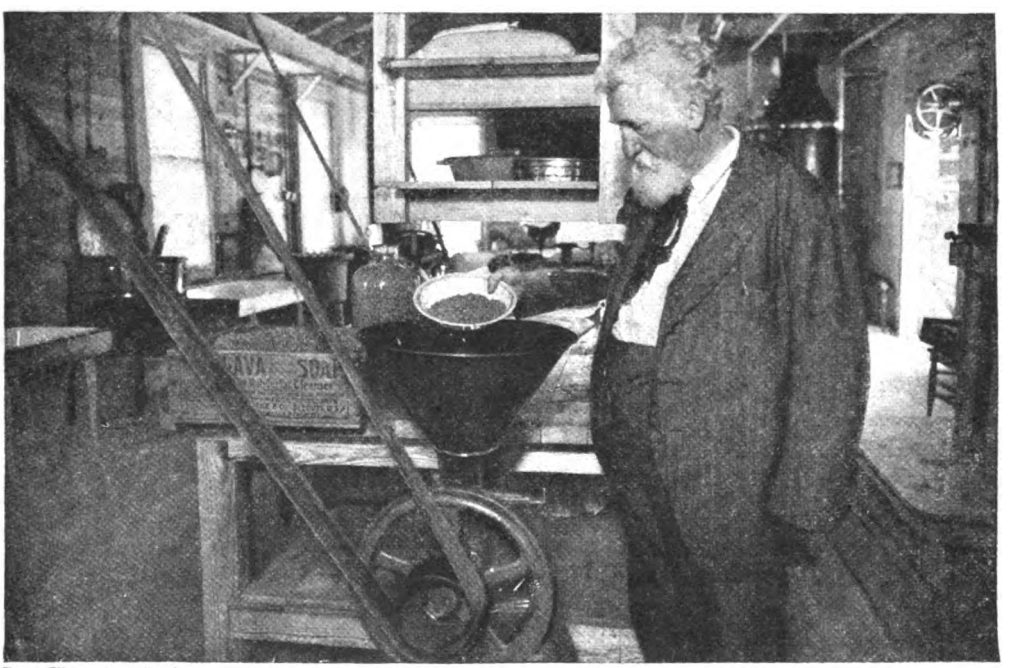
do the suns pour their light and heat into the ether, but also that the ether reciprocates by restoring to the suns their lost light and heat, through the intense bombardment or hammering of their masses by etheric vibrations. Professor Jeffries, of Cleveland, Ohio, a noted scientist, has reached the brilliant conclusion that it is the ether that keeps the suns hot.

Let us take one more look at the ether:

Every particle of matter on the earth is in a state of intense vibration. All living things on the earth are, by reflected light, sending their images out into the ether, where they will go on for ever. Even every thought we think shakes the ether. We may die, but the impressions which we make on the ether are immortal.

If we could fly out from the earth with a speed sufficiently great, we would overtake the rays of reflected light which left the earth thousands and millions of years ago. If we were possessed of infinite vision, we could, as we went, look back and see the history of the earth unravel. We could see all of our cities fade away into the primal forest. We could see man return to the hill-cavern, and then back to the ape-like animal, swinging on the trees of a tropical jungle. Farther back still to the lemur, and back —away back—to a little agile lizard in the reptilian age, flitting about and living by its wits among the giant saurians, which we should see wallowing in the ancient ooze.

We should see our ancestry unwind back to the fish, from whose fins the mind has forged the human hands. And from the fish we should finally see evolution devolve back to the moneron, a little speck of protoplasm, the parent of all life, plunged in the azoic sea.



Press Illustrating Service

"WE MAY DIE, BUT THE IMPRESSIONS THAT WE MAKE ON THE ETHER ARE IMMORTAL"

So Hudson Maxim expresses in a phrase the scientific hypothesis that the impulses that our bodies originate never come to a final (mathematically speaking) rest. This picture of the distinguished inventor of Maximite shows him at work in his experimental laboratory at Landing, New Jersey.

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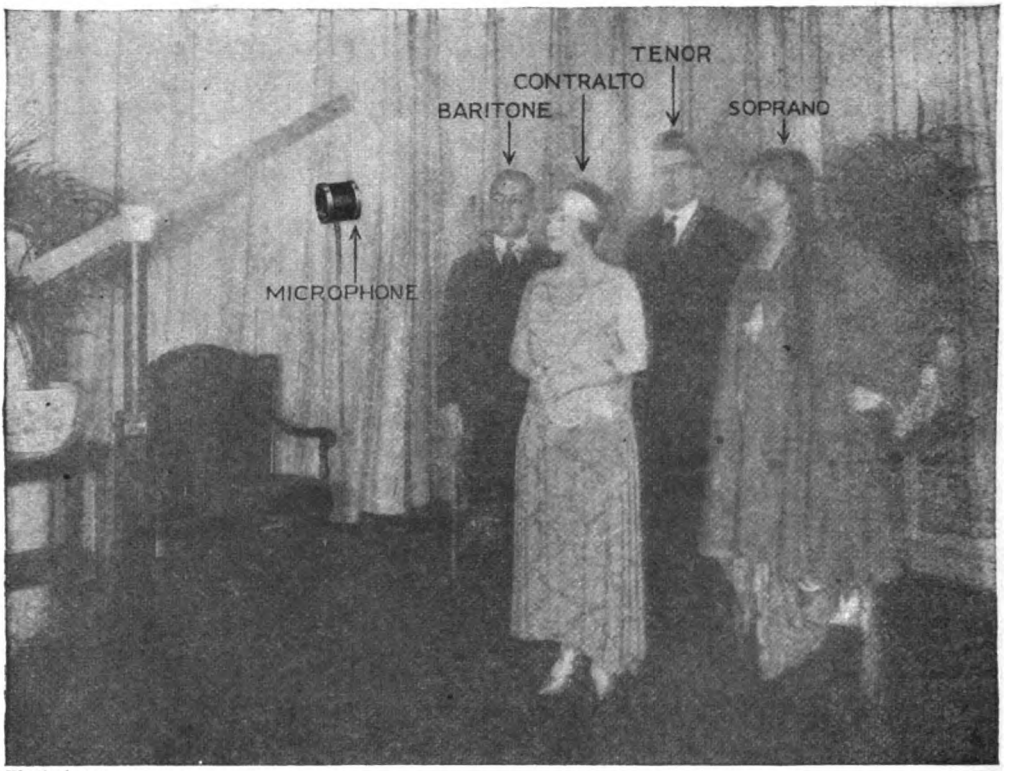

Westinghouse

HIGH VOICES HAVE MORE INTENSITY

Consequently the sopranos and tenors are placed farther from the microphone than the contraltos, baritones and basses, in order to give proper values to the transmsision.

Mixing Music in the Microphone

How the modern radio impresario is overcoming the mechanical difficulties that arise in the broadcasting of *ensemble* music in which each voice and each instrument must be blended into an harmonious whole

By C. L. LE MASSENA AND WILLIAM H. EASTON, Ph.D.

ANY new invention that becomes popular too suddenly, before its details have been thoroughly worked out, is apt to run foul of unexpected difficulties. Such was the case with the automobile, the submarine and the airplane. And such likewise has been the case with radio.

Urged onward by a too eager public, hundreds of broadcasting stations started operations with little knowledge of either the scientific or the artistic principles involved; in consequence, the noble art of music was in danger of being dragged into disrepute.

Music by radio presents many different and intricate scientific problems, such as the proper selecting, arranging and handling of the various elements that go to make up a musical production.

Radio broadcasting began with the phonograph, the player-piano and vocal

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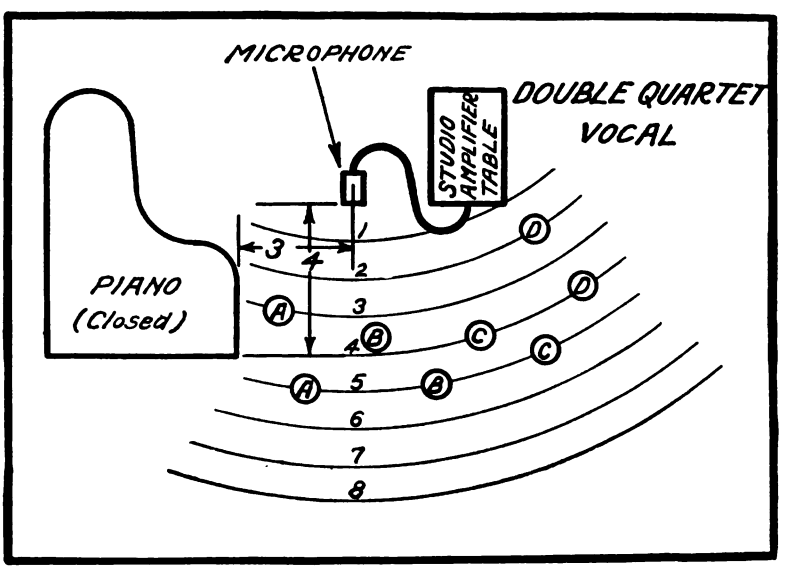
solos. Then came a rush of vocal and instrumental duets, trios, quartets, bands, orchestras and choruses. Now, groups of vocalists and instrumentalists, large and small, cannot be handled at random. In the concert hall the several divisions are carefully placed in accordance with the experience of many years, and because the sound waves have ample room to expand and travel to the ears of the audience, excellent results are obtained.

But in the broadcasting studio the space is small. There is no audience, only the microphone, and all tones have to reach this single point with exactly the right intensity. Nor are the instruments played in the same plane. Double-bass players stand, all others sit. The violin and viola are held under the chin, the cello between the knees. Flutes, fifes, trumpets and bugles are held high. Other wind instruments are kept low. Moreover, the players sit behind music-stands, so that the sounds are deflected upward from the music sheets. Finally, the characteristics of the average microphone are quite different from those of the human ear. It responds to certain voices much more readily than to others. In consequence, a grouping in the studio that would be satisfactory to a person who stands at the microphone might not be at all pleasing when heard by the radio audience.

Phonograph recording difficulties were overcome because the records could be studied before marketing them. Mistakes by singers or a wrong grouping of an orchestra were mere matters of detail. Poor molds were destroyed and new ones made until a satisfactory one was secured. But this is not the case with radio. Sounds, as originally emitted, go at once to the public. They cannot be recalled. Radio music must attain perfection through open experiment. The studio managers of all the better broadcasting stations listen in on radio receivers constantly, in order to check the character of the performances, and many stations have official outside critics who phone in comments and suggestions. Such arrangements are valuable at all times, but to put entire dependence upon them



THE CORRECT POSITION FOR A DOUBLE QUARTET

The basses and baritones (indicated by A) should be placed nearest to the microphone. The contraltos (B) come next; then the sopranos (C), and then the tenors (D). The arrangement takes into consideration the importance of the parts sung as well as the tone values of the voices.

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Westinghouse

A Correct Grouping

Here the violin, saxophone and banjo—the more quiet instruments that carry the melody—are placed in the foreground, while the penetrating brasses and the loud percussion instruments, such as the piano and drums, are placed in the rear.

means too much public experimentation. Hence, accurate standards, that can be applied in advance, have been sorely needed.

In order to develop such standards in transmission of music, the Westinghouse Company assigned the task to A. G. Popcke, one of its engineers, who is also a musician. He spent months at the work, studying the radio qualities of every kind of sound and every possible combination of sounds. In this task he was assisted by the "modulation meter," an instrument specially developed by the Westinghouse Company for the purpose. This instrument, which resembles an ordinary ammeter, is connected in the microphone circuit and indicates the strength of the currents controlled by the sounds that reach the microphone. It has a scale from 1 to 100. Sounds producing currents below 10 on this scale are too weak to hear, while those producing currents above 90 are so strong as to cause blasting. Consequently, by watching this instrument, the modern operator obtains exact information as to the values of the sounds that are actually being broadcast.

If the modulation meter registers too high during a selection, the amplification of the microphone current is reduced, or the microphone is moved away from the musicians, until the sounds are softened sufficiently to be properly transmitted. If the meter registers too low, the amplification is increased or the microphone is brought nearer. In a similar manner, the radio intensity of each particular voice and instrument can be determined, thus giving exact data for groupings.

Some of Mr. Popcke's conclusions are at variance with what might be expected. Thus, for solo work, a bass singer must stand nearer the microphone than a tenor or a contralto, while a soprano must

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Westinghouse

—and a Wrong Grouping

Loud instruments placed near the microphone tend to "blast" the transmission and to drown out the weaker-voiced instruments in the background. The drums are special offenders, and often ruin the broadcasting of orchestral ensembles.

stand farther away than any other singer. In a well-balanced mixed quartet, the contralto and bass are nearest, the soprano and tenor at greater distances. With an orchestra, the cello and double-bass are nearest, and the violins and violas are ranged in a semicircle behind the cello. The flute and clarinet occupy the next rank, the brass instruments next, and the drums are placed in a far corner. Singers of comic songs must stand closer to the microphone than singers of classical music, because the words of comic songs are the most important part and must be heard distinctly, whereas in classical songs, words and music are equally important. Where instruments and parts are duplicated (as with two violins, mandolins or saxophones) the players must play in exact synchronism or the sounds will become blurred.

The studio must be so constructed and draped that all echoes and reverberations are eliminated. There are different ways of doing this. In the WGI studio at Medford Hillside, Mass., the walls and ceiling are treated with a special acoustic felt, after the method that is employed in record-reproducing studios. The floor is covered with a heavy carpet. The WGY studio at Schenectady has a large rug on the floor and the windows are draped with loose, light curtains. In the Navy Department studio, NOF, at Anacostia, special sound-damping devices and paraphernalia are rigged up on the walls, ceiling and floor so as to prevent reverberation of sound waves and to insure good reproduction. In the Westinghouse studios the practice varies. At KDKA, Pittsburgh, and WBZ, Springfield, shirred burlap covers the walls and ceilings and heavy carpets cover the floor. The Newark studio, WJZ, is specially constructed of sound deadening

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material, but experiment showed that the room was so long that echoes were formed. It was necessary to hang curtains across the middle of the room to eliminate this difficulty.

The result of these precautions is that to one speaking in a properly constructed studio his voice feels dead. We are used to hearing reverberations when we speak and the suppression of them seems unnatural. The absence of all outside noises helps to emphasize this effect.

The piano is, as always, a special problem. When used for accompanying singers, it must be distinctly heard but must not drown the noises. Careful study was therefore given to the relative positions of microphone, piano, and soloists, and also duets, quartets and choruses. It was found that the greater the number of voices, the greater must be the intensity of the piano music at the microphone. Groupings were therefore worked out for each combination of singers. Mr. Popcke has reduced his findings to a series of charts, two of which are reproduced. These charts are used by the studio managers of the four Westinghouse stations—KDKA, Pittsburgh, WJZ, Newark, N. J., KYW, Chicago, Ill., and WBZ Springfield, Mass. Thus, all stations operate according to the same standards. Other stations are likewise experimenting along these lines. For example, at the General Electric station, WGY, at Schenectady, more than one transmitter is used for the broadcasting of a church service where the choir, the minister and the organ are in three different places, not in close proximity. In this instance, three microphones are used in parallel. Three microphones are used in broadcasting WGI programs from Medford Hillside; two are used exclusively for musical entertainments, orchestral concerts, choruses and solos and one is used for speaking.

The NOF station at Anacostia, D. C., is engaged in experimental work along lines of reproduction of speech and music, under the direction of the Bureau of Engineering, Navy Department. Much progress has been made in efforts to reproduce accurately and with correct intensity all sound waves. By means of a special microphone which is non-resonant to frequencies below 3,000 cycles, together with the proper adjustment of the vacuum transmitter circuits, sound waves of all frequencies below 3,000 cycles are reproduced well with respect to intensity and frequency. While this station has no fixed activities, it broadcasts band concerts twice weekly as part of the effort to solve one of the major problems under consideration, *viz.*, the quality of tone modulation. When one to three artists are singing or playing only one microphone is used, while in the case of an orchestra two are used. The instruments are placed at various distances from the singers or players according to the nature of the instruments and the classes of singers who are performing.

The acoustics of a studio represent a problem in three dimensions.

Suppose, for example, high C is struck on the piano. On exploring every cubic foot of the studio's interior, a point will be found where, due to the various echoes and reflected sound waves in the room, that note will be received at its best value. Now strike a deep bass note, and the chances are that that particular note will be best received at some other point because its waves will be echoed and reflected in a different manner. Obviously, therefore, the location at which a piano selection as a whole is best received will be a compromise; that is to say, will be the point where only the majority of the notes will best be received. Conditions are, of course, still worse when an orchestra is playing.

The consequence of this situation is that before using the charts the acoustic properties of the particular studio must be thoroughly known. The microphone must be placed in the best spot for the particular music to be broadcast and the

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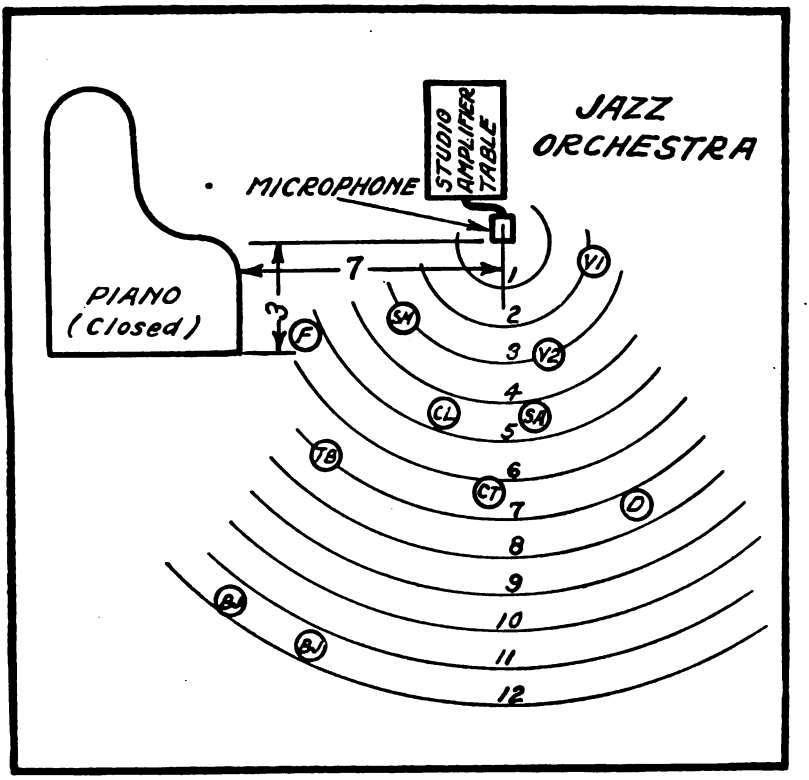

HOW AN ORCHESTRA SHOULD BE ARRANGED

The first and second violins (V1, V2) and the melody saxophone (SM) are placed close to the microphone; farther away are placed the saxophone that plays the accompaniments (SA), the flute (F), and the clarinet (CL). In the background are the cornet (CT), the trombone (TB), the drums (D), and the banjos (BJ).

musicians then arranged in accordance with the chart. However, if the studio is perfectly echoless and reflects no sound waves whatever, then all points within it will be equally good for reception. This degree of perfection is probably impossible to secure, but evidently the better the sound-proofing the less the distortion and the better the artistic results. KDKA's new studio, for example, has sound-proof walls; the walls, ceiling, and floor are covered with a heavy layer of felt and the walls and ceilings are draped and the floor has a thick carpet. The result is that the room is practically echoless, and the music broadcast is notably excellent.

During the pioneer days of radio there was no precedent to follow and little experimental knowledge to guide; therefore guesswork was inevitable. In broadcasting the Mozart opera, *The Impresario,* from WJZ last winter, the five singers were rehearsed before a dummy microphone, and were shifted so as to bring each singer before the recording instrument in turn. When several sang together, their heads came in close proximity. Today this arrangement would not be employed. The groupings would follow the new scientific method as described, unless one of the artists possessed an unusually powerful voice, in which case proper adjustment would have to be made.

Much more difficult than broadcasting music from the studio is the broadcasting of grand opera from the opera house. The pioneer work of this kind was done by the Chicago Westinghouse station

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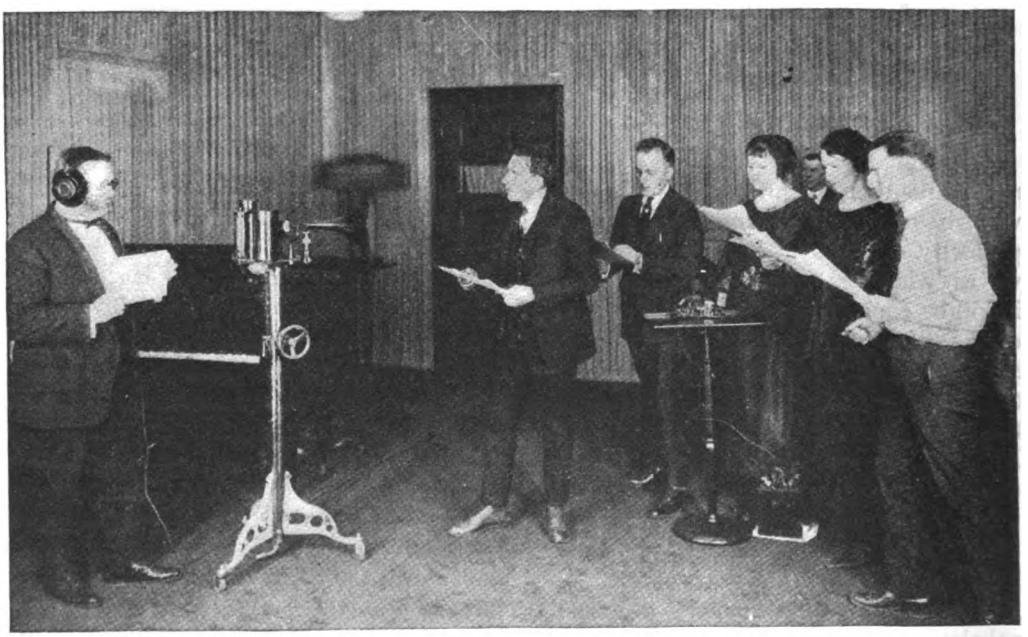
KYW which transmitted practically every performance of the Chicago Opera Company during the 1921-22 season. For reasons that are obvious, no single microphone could handle soloists, chorus and orchestra. Several microphones were therefore installed in various parts of the stage and house. These were connected to a little switchboard in the wings, and an operator connected in first one and then another in accordance with the character, volume and location of the music and singers. The results, while interesting from an experimental standpoint, were not all that could be desired artistically.

The same may be said of attempts to broadcast symphony concerts where a large number of musicians are employed with but a single microphone and no scientific grouping of the instrumental bodies.

To get the best results, operas should be performed in specially designed studios and with specially selected forces. Not every opera is suitable for this purpose. William Wade Hinshaw, producer of Mozart's *The Impresario*, claims that only the lighter forms, where solo singers do most of the work, can be broadcast.

Many new problems have to be solved in order to obtain an operatic performance by radio of the highest artistic character. Large orchestras or choral groups are just as much out of place in a broadcasting studio as they are in a phonograph recording laboratory, because the fewer the combinations employed, the better is the effect. Scientific grouping and selection is therefore imperative. Soloists, chorus and orchestra must be arranged so that each group can function independently or conjointly as occasion demands. All of these things require further artistic and scientific investigation and experiment until a *modus operandi* is devised that can cope with grand opera requirements. Then radio music will have fulfilled its possibilities.



International

AN "UNDRESS PERFORMANCE" OF A PLAY

The broadcasting of a theatrical production from a studio (in this case from WGY) not only permits the actors to appear without costume and make-up, but enables each performer to advance and talk directly into the microphone. The director listens in with padded earphones and coaches his cast by means of instructions written on cards.

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FOUR WAYS TO GET GOOD MODULATION

PART I

The four standard methods may be listed as (1), the use of the microphone in the antenna circuit for low-power transmission; (2), the use of a magnetic transformer; (3), grid modulation and (4), Heising modulation. The first two of these methods are here described by one of the foremost authorities in this field—

PROF. J. H. MORECROFT

IF we breathe quietly the lung pressure forces air in and out through the throat in a fairly uniform stream, but if we talk or sing the air emerges through the throat chambers in a series of puffs. A delicate mechanism for indicating air pressure placed near the mouth would show that the air pressure varied periodically above and below its normal value. The frequency of this pressure variation is determined by the pitch of the voice and the intensity or strength of the voice determines the amount by which the pressure of the air varies from its normal value. If the pressure-indicating device were so arranged, we might connect to it a lightweight pencil, and this, through a suitable system of motion-magnifying levers, would enable us actually to draw the form of the air-pressure waves.

Typical curves which might be thus obtained are shown in Figure 1; curve *a* is for a comparatively weak violin note about one octave above middle C of the piano, while curve *b* is for a more intense note, of more complex quality, with a pitch of about fifty a second.

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The problem in radio telephony is to let these pressure waves of the voice act on the apparatus at the broadcasting station in such a way that a simple receiving circuit will send off pressure waves from the diaphragm of the head phones which are sufficiently like those actuating the transmitter for the voice to be clear and recognizable. If the pressure waves at the transmitting and receiving stations were actually drawn by an instrument of the kind I have suggested, the eye would probably not recognize them as the same, yet so wonderful an instrument is the human ear that it, in combination with the brain processes by which we are made conscientious of sound, would interpret them as the same.

The waves shown in Figures 1A and 1B are periodic waves; that is, the wave forms are repeated many times with approximately the same shape. This is the kind of wave given off when a vowel sound is sung, or a violin string bowed or a simple note on a wind instrument is sounded.

The voice contains many sounds, however, which are not periodic; sounds in which the wave forms do not repeat themselves. In this class fall all the consonants—the explosive sounds of the voice, such as p, k, t and s. The periodic or vowel sounds of the voice are much easier to reproduce by radio than are these consonants, in fact, practically all the improvement which will be made in the quality of radiophone transmission will come about by changes in the apparatus, at transmitter and receiver, to "get through" more of these consonant sounds. The next time you listen in with a loud speaker, try to analyze the sounds you hear and estimate how many of the consonants are coming through with their proper relation to the vowel sounds; you will be surprised to find how few of the consonants you actually hear. What you really hear is a series of vowel sounds; the brain generally "injects" the consonants to a sufficient extent to make the speech intelligible; when it doesn't do so you do not understand the speech. There may be plenty of noise there but when you listen to it carefully you will find that it is actually made of sounds that are practically nothing but vowels.

FIGURE 1A

A graphic record of a high musical note of a violin, one octave above middle C. Compare this record with that on the facing page.

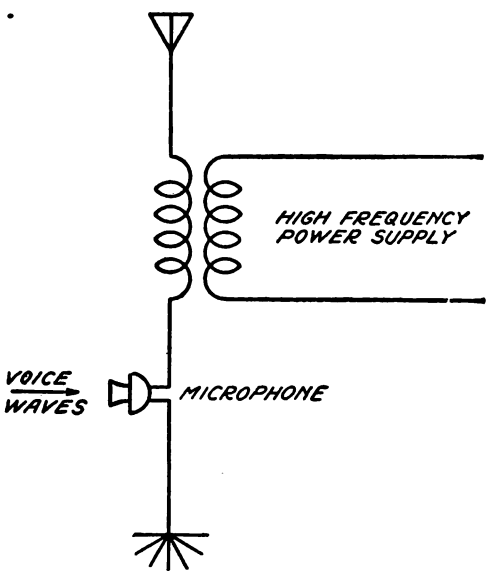

FIGURE 2

The most simple scheme for modulation. The microphone is connected in the ground lead.

At the broadcasting stations it is necessary to generate and radiate high-frequency, electromagnetic waves from the antenna, the frequency of which shall be essentially constant but the amplitude or intensity of which shall vary in a manner corresponding to the form of the pressure waves of the voice. The frequency of the waves sent off from the antenna must be very high (say of the

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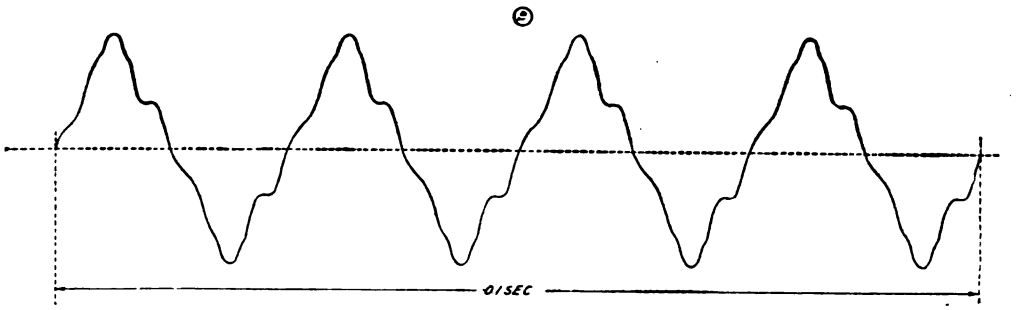

FIGURE 1B

A graphic record of a low note of a violin, of less than 50 vibrations a second.

order of one million a second), or else not much power will be radiated and the resulting signal at the receiving station will be correspondingly weak. The task of the radio engineer is, therefore, to generate at the station plenty of high-frequency power and arrange the generating apparatus in such a way that the minute power of the voice, measured possibly in the thousandths of a watt, can accurately control its activity. This minute power of the voice must be able to control perhaps a horsepower of electrical oscillations and control this power so decisively that it changes from practically nothing to a horsepower or more hundreds and thousands of times a second.

In some of the experiments in trans-oceanic telephony this extremely small power of the voice controlled the flow of energy from a two hundred kilowatt generator—not only made this tremendous amount of energy to flow and cease flowing into the antenna hundreds of times a second but made the form of this periodic fluctuation in energy flow conform closely to the pressure wave of the voice.

We shall consider some of the schemes by which this voice control of the antenna power is brought about.

The most obvious scheme and that first tried, is to put the microphone directly in the antenna as indicated in Figure 2. The high-frequency power for radiation from the antenna is supplied from some kind of a machine to the antenna through the coupling transformer shown.

The microphone consists essentially of a mass of closely packed carbon granules through which the current flows. Practically all of the resistance of such a mass of granules is at the points of contact of the various particles and this contact resistance varies greatly with the amount of pressure exerted on the granules. The metal diaphragm of the microphone, against which we talk, presses lightly against the mass of granules; hence it follows that by varying the pressure on the diaphragm the resistance of the granule contacts may be greatly changed.

When the voice waves impinge on the diaphragm it alternately presses and releases the carbon granules and so varies the resistance of the microphone as a whole.

With an arrangement like that given in Figure 2 the amount of high-frequency current that flows in the antenna depends directly upon the antenna circuit resistance and this is affected by the resistance of the microphone, because whatever current flows in the antenna must evidently flow also through the microphone. Hence the amount of antenna current, which determines the signal strength at the distant receiving station, fluctuates according to the voice waves that impinge upon the microphone diaphragm.

This arrangement has the advantage of simplicity and it was used in practically all of the early attempts at radio tele-

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phony; it has many undesirable characteristics, however, and is seldom used today. Comparatively small amounts of power can be controlled in this fashion, as the microphone can carry only small currents without overheating. The scheme is very inefficient; 50 per cent or more of the high-frequency power supplied to the antenna is used up as heat in the microphone itself, and the amplitude of the antenna current does not directly follow the voice-wave pressure on the diaphragm of the microphone so that the variation of antenna current does *not* truthfully represent the voice wave; the *modulation* is imperfect.

Another scheme which has been used to some extent at both small and large radio transmitting stations is that indicated in Figure 3.

The high-frequency power is supplied as before from a machine or tube through the magnetic coupling as shown, but instead of placing the microphone in the antenna circuit, an iron-core coil is so placed. This iron-core coil is fitted with two windings, one connected in the antenna circuit and the other carrying a continuous current; the fluctuation of this continuous current follows the voice waves because the microphone is placed in series with this winding, as shown on the diagram.

The modulation in this scheme is accomplished by detuning the antenna. To absorb considerable amounts of power from the power supply the antenna must be accurately tuned to the frequency furnished by the power supply; any departure from this tuning will at once cut down the amount of power supplied to the antenna. Due to the magnetic properties of the iron core the amount of inductance of the coil depends upon the amount of current flowing in winding B so that the tuning and detuning of the antenna follow the fluctuations of the continuous current in winding B and this in turn, depending upon the resistance of the microphone, fol-

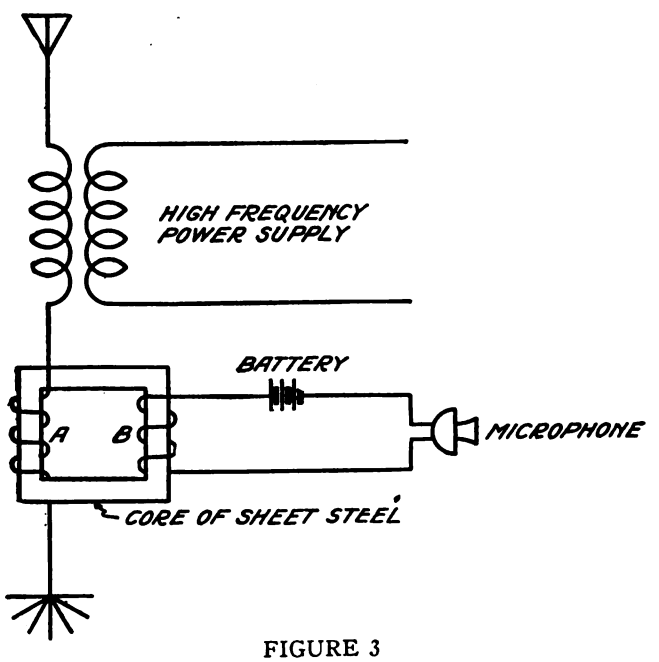

FIGURE 3

Another system for modulating in the antenna; it is called "magnetic modulation." This is accomplished by a special type of transformer which varies the tuning of the antenna circuit in accordance with the voice waves that are impressed upon the microphone.

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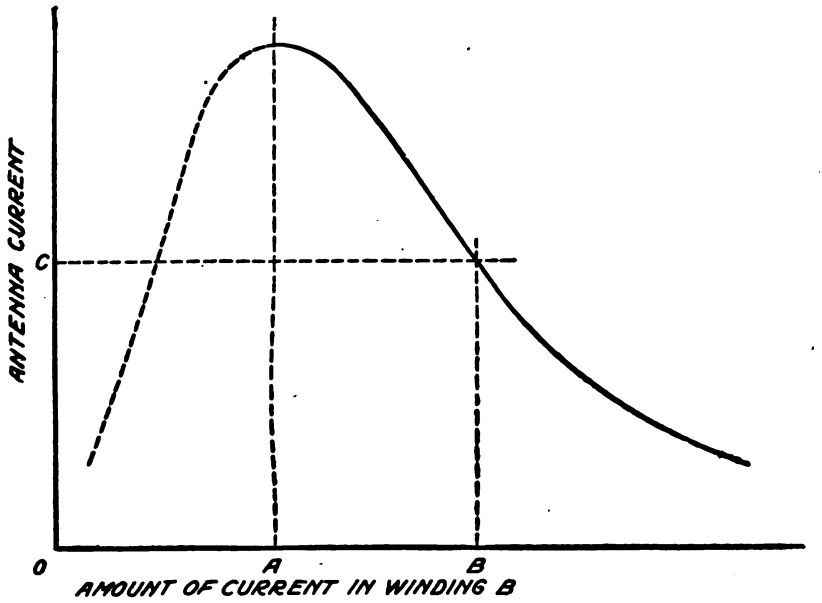

FIGURE 4

This curve shows the variation of the antenna current plotted against the variation of the microphone current. A change in the microphone current causes a change in the antenna current; in this way the radio waves are shaped into the form of voice waves.

lows the pressure of the voice-wave.

The variation of antenna current with the amount of continuous current in winding B is about as shown in Figure 4; the workable part of the curve is that shown in the full line. With an amount of continuous current equal to A the antenna is tuned to the power supply; so the antenna receives a maximum of power; for currents greater than A the antenna current proportionately decreases. Normally the antenna current is equal to OC and the amount of current in the winding B of the coil is OB. As the pressure on the microphone increases the current through B increases, thus decreasing the antenna current and if the pressure on the microphone decreases, thus increasing the resistance of the microphone the continuous current through B decreases and the antenna current as a result of this increases proportionately.

When this scheme was actually used for controlling the large Alexanderson alternator at New Brunswick it was found necessary to use several condensers suitably connected and the continuous current through coil B was not controlled directly by the microphone but was controlled by some large vacuum tubes, the grids of which were actuated by the microphone.

As the iron core is subjected to high-frequency magnetic reversals, because of the antenna current through coil A, it is necessary to build the core of thin sheet steel plates and these plates must be carefully insulated from each other. The plates used are generally not more than two or three thousandths of an inch in thickness.

"What Is the Best Kind of Modulation for My Set?"

In the next article of this series Prof. Morecroft will point out the way to answer this question. Specifically, he will describe the grid modulation (adapted for single-tube receiving sets) and the famous Heising modulation —the most efficient of all, and adapted to all amateur transmitting stations.

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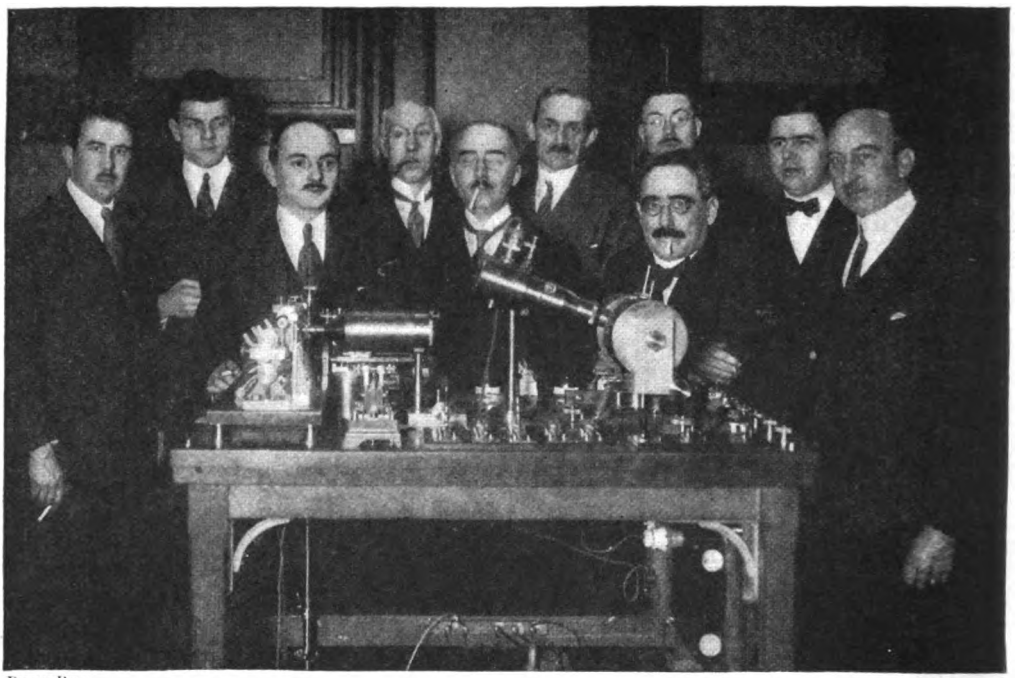

Brown Bros.

THE INVENTOR GIVES A DEMONSTRATION

When M. Edouard Belin of Paris recently arrived in New York, he exhibited his latest device before a group of scientists. In the above picture the inventor is the fifth man from the left.

Secret Signals by Radio

Up to the present time all signals transmitted by radio have been regarded as "broadcast," to be picked up by any receiving station within the transmitting station's range. The ingenious apparatus described in this article shows how the transmitted signals can be recorded intelligibly only by special receiving sets—thus opening up the possibilities of restricting the messages or pictures within any desired limits

By PAUL McGINNIS

THE chances of intercepting radio messages sent by the "crypto" are so small that Edouard Belin, its inventor, knows no French shrug of the shoulders which will describe them. It is impossible to eavesdrop on its messages—if anything is impossible in radio.

The new device with which the noted French inventor has surprised American scientists in his visit to New York is used with his invention for transmitting photographs and written messages both by land wires and by radio which he is introducing in this country.

Six adjustable disks control transmission, and their combination is as difficult to guess as the combination of a lock on a bank safe. They split seconds for the transmitter. The transmission itself is an invention of world fame. It is able to transmit signatures accurately enough to be acceptable to banks. By it photographs and messages have been sent successfully from Paris to Bar Harbor, Me., and also from Beirut, Syria, to Paris.

The picture or photographed message to be sent is transferred to a brass cylinder and treated with chemicals so that it

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dissolves and leaves only the emulsion. As the cylinder turns it makes electrical contact with a small point of metal resting upon the emulsion. The current that flows through the cylinder and the point of metal is varied according to the resistance of the light and dark parts of the emulsion.

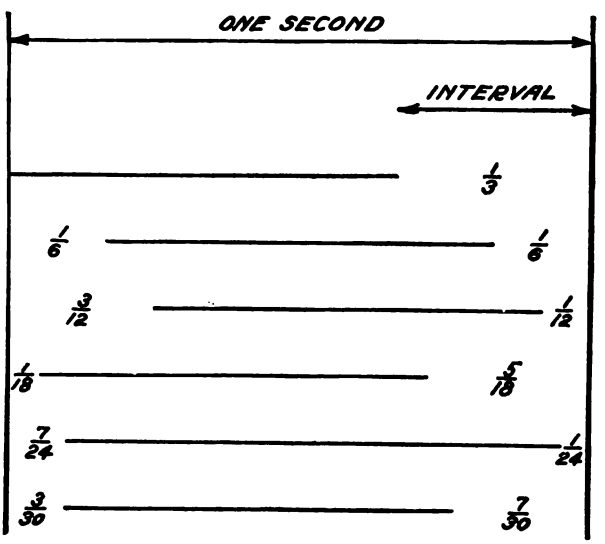
The current, with its variations caused by the light and shade of the photograph, is then superimposed upon a carrier wave and sent out in the usual manner employed to broadcast speech and music. The common modulation transformer is employed for this purpose.

The photographic message is received upon a sensitized cylinder similar to that used in transmitting. The two cylinders are timed to synchronism by a transmitted sound much like that of the metronome used for teaching rhythm in piano playing.

When the broadcast photograph is caught by the ordinary antenna and vacuum tube receiver, its pulsating current is led to an oscillograph where a loop of fine wire suspended in a strong magnetic field bears a mirror about the size of a pin-head. This small loop of wire moves back and forth as the current becomes stronger or weaker and changes the direction of an intense beam of light reflected by the mirror.

The beam of light moves over a glass slide which varies from opaqueness at one end to transparency at the other. After the light has passed through the slide, a lens concentrates it upon the sensitized revolving cylinder and reproduces there a small strip of the picture at each revolution.

With these comparatively simple instruments, the picture can be intercepted and taken from the air by anyone, but with the addition of the crypto the task of listening-in becomes hopeless. One small strip of the picture or message sent out by one revolution of the transmitting cylinder might be received perfectly, but as the interval between revolutions is constantly changed the strips would not coincide.



HOW THE TRANSMITTING PERIOD IS VARIED

HOW THE RADIO SIGNALS ARE "SCRAMBLED"

FIGURE 1: *This chart shows how the "crypto" scrambles a picture or message transmitted by radio and makes it practically impossible for another receiver that is not equipped with it to solve or unravel the otherwise meaningless jumble of signals.*

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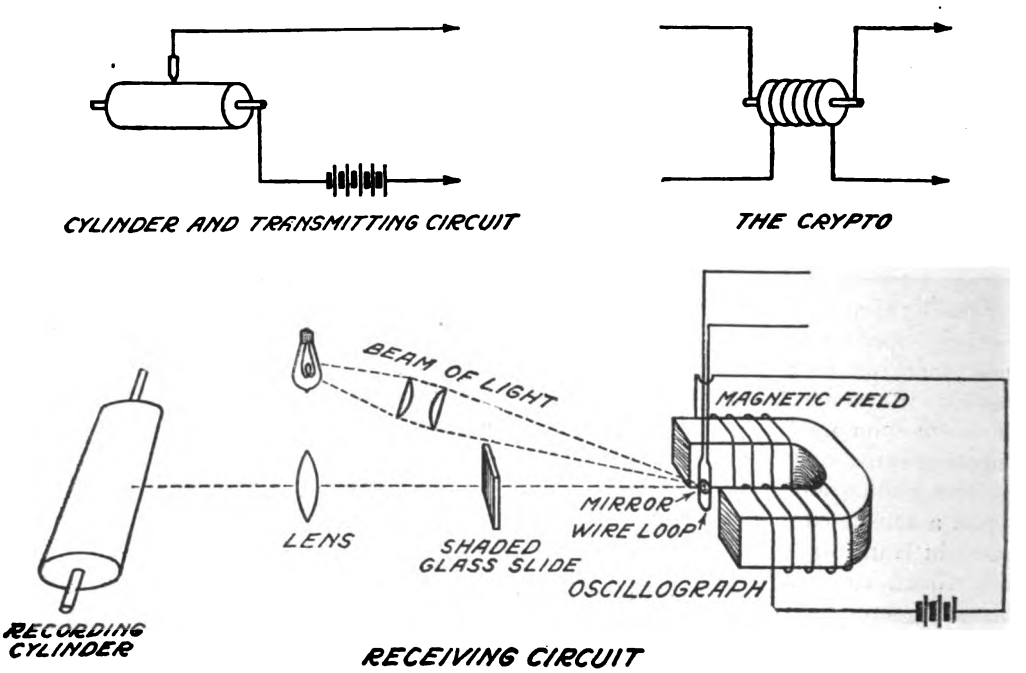

HOW THE DEVICE WORKS

FIGURE 2: *The transmitting cylinder upon which the picture is made in bas relief varies an electrical current which is transmitted to the crypto and sent out over a telephone wire or by radio. At the receiving end the current is led into the reconverting apparatus (as shown above) and is changed into a light wave, of varying intensity, which is traced upon another cylinder, thus reproducing the picture. A crypto is used at both ends to scramble and unscramble the transmitted impulses and the two devices are run synchronously.*

If each revolution of the cylinder requires 2/3 of a second, there will be an interval of 1/3 of a second during which time the cylinder does not revolve or transmit. It is this inactive interval which is made use of to insure secrecy. This is done by distributing it in various combinations, part before and part after the given revolution.

As shown in Figure 1, the first revolution occupies 2/3 of the first second, after which there is an interval of 1/3 of a second. Since a different combination is used in the second revolution, the 1/3 of the first revolution is added to the 1/6 which precedes the second revolution, making a total of 1/2 second between the transmission of the first and second strips of the messages. The combined interval between the second and third strips is 5/12 of a second; between the third and fourth it is 13/36.

Unless the receiving apparatus responds exactly to these delicately timed intervals, the received message will be nothing but meaningless lines of light and shade.

The crypto controls the intervals by means of its six adjustable disks which move in synchronism with the revolving cylinder. Each disk bears the figures from 0 to 9, and can be adjusted to any figure in a moment. The six disks may be combined in 999,999 different ways. The chance to intercept the message, therefore, even with the aid of another crypto, is one in a million.

Ordinarily an inventor might be content to call such a machine a secret instrument and let it go at that, but Belin has gone one step farther. He has considered the possibility of an ear or an instrument sensitive enough to detect the intervals. To eliminate this he has dis-

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guised them. What are called "parasites" or unintelligible signals are automatically sent out during the intervals. When they are transcribed, they form a meaningless strip of light and shade, but they are so much like a part of the message that any listening in would be unable to tell where the message stopped and the "parasite" began.

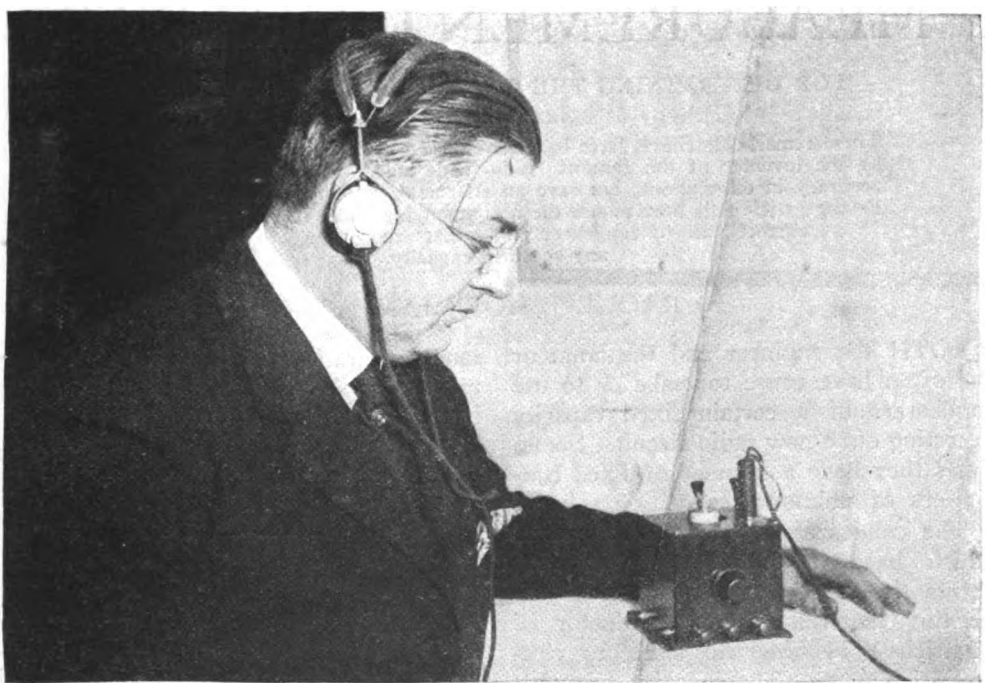
The device has its shortcomings when used with radio, but it is a large step in the direction of secrecy and so far it is the only invention which completely foils the eavesdropper.

Both static and interference from other stations will alter the current received and consequently affect the picture or message photographed on the receiving cylinder. But with added equipment, the invention is considered to be practical. A loop antenna will reduce interference from transmitting stations and from static almost half, and the methods of Marconi and others in sending unidirectional waves will reduce other objectionable features by another large fraction.

Marconi's beam of waves, sent out by an antenna shaped like the reflector of an automobile headlight,* cannot be intercepted by any station not directly in their narrow path. They may easily be applied to the crypto.

Belin's apparatus is now being installed to transmit press photographs in the United States. This is only the beginning of its service.

*See POPULAR RADIO *for March, 1923.*



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A UNIQUE RECEIVER IN A FOUR-INCH BOX

This midget set contains a dry-cell tube rheostat and a tuning transformer, and is capable of picking up signals from distant stations without the use of amplifiers. This receiver enables its designer, Dr. R. S. Piper, to hear broadcast programs from all over the United States from his home in Chicago. It is certainly one of the most powerful and effective receiving sets of so small a size and compact arrangement that has yet been constructed.

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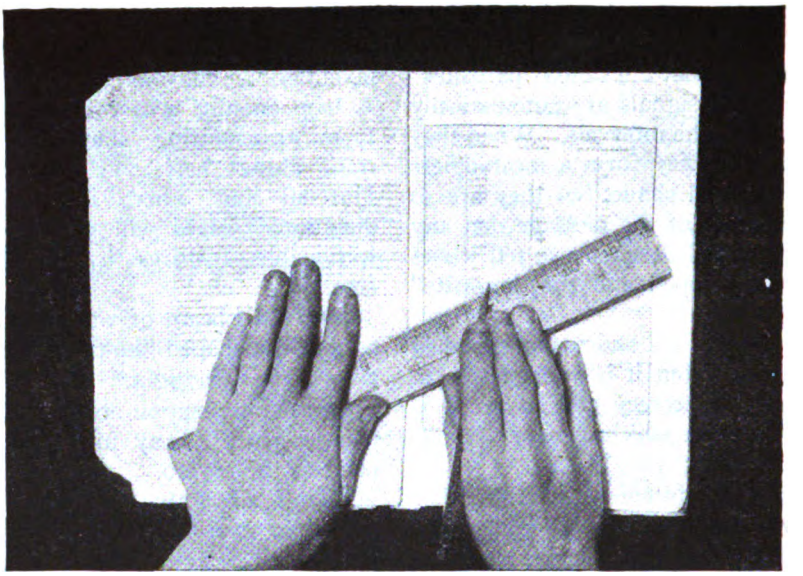

ALL YOU NEED IS A RULER, A PENCIL AND A PAIR OF HANDS

By means of the table on the opposite page the amateur who builds his own apparatus may calculate in an instant the design for a condenser that will have a pre-determined capacity, or find out the capacity of a condenser that is already built.

MEASUREMENT CHARTS

FOR DETERMINING THE CAPACITY OF A CONDENSER

ARTICLE No. 3

These remarkable charts have been developed especially for POPULAR RADIO by the inventor of the famous "radio slide rule." They not only insure accuracy in calculations, but save an enormous amount of time. The following article tells how to use the accompanying chart for determining the correct sizes of condenser plates that are designed to obtain any specified capacity.

By RAOUL J. HOFFMAN, A.M.E.

BOTH the engineer and the amateur often have cause to make or to use condensers of a certain fixed capacity in testing out a new radio circuit. Sometimes they have a number of fixed condensers of unknown capacity on hand.

The condenser is an electrical device which has two or more conducting sheets that are separated by some insulating material (a non-conductor of electricity) in order to store up electrostatic energy. The capacity of such a condenser, which is usually measured in microfarads (mfd.) depends entirely upon the active area of the plates or sheets of conducting material, the distance separating them, and the kind of material (dielectric or insulator) which is used to separate them.

The formula for the capacity of a condenser follows:

$$C = \frac{A\,K\,.0000002248}{T}$$

where

A = the area of the plates in square inches
K = the dielectric constant of the insulating material (given below)
T = the thickness of the insulating material, in inches

and

C = the capacity of the condenser in mfds.

The dielectric constants for various materials are:

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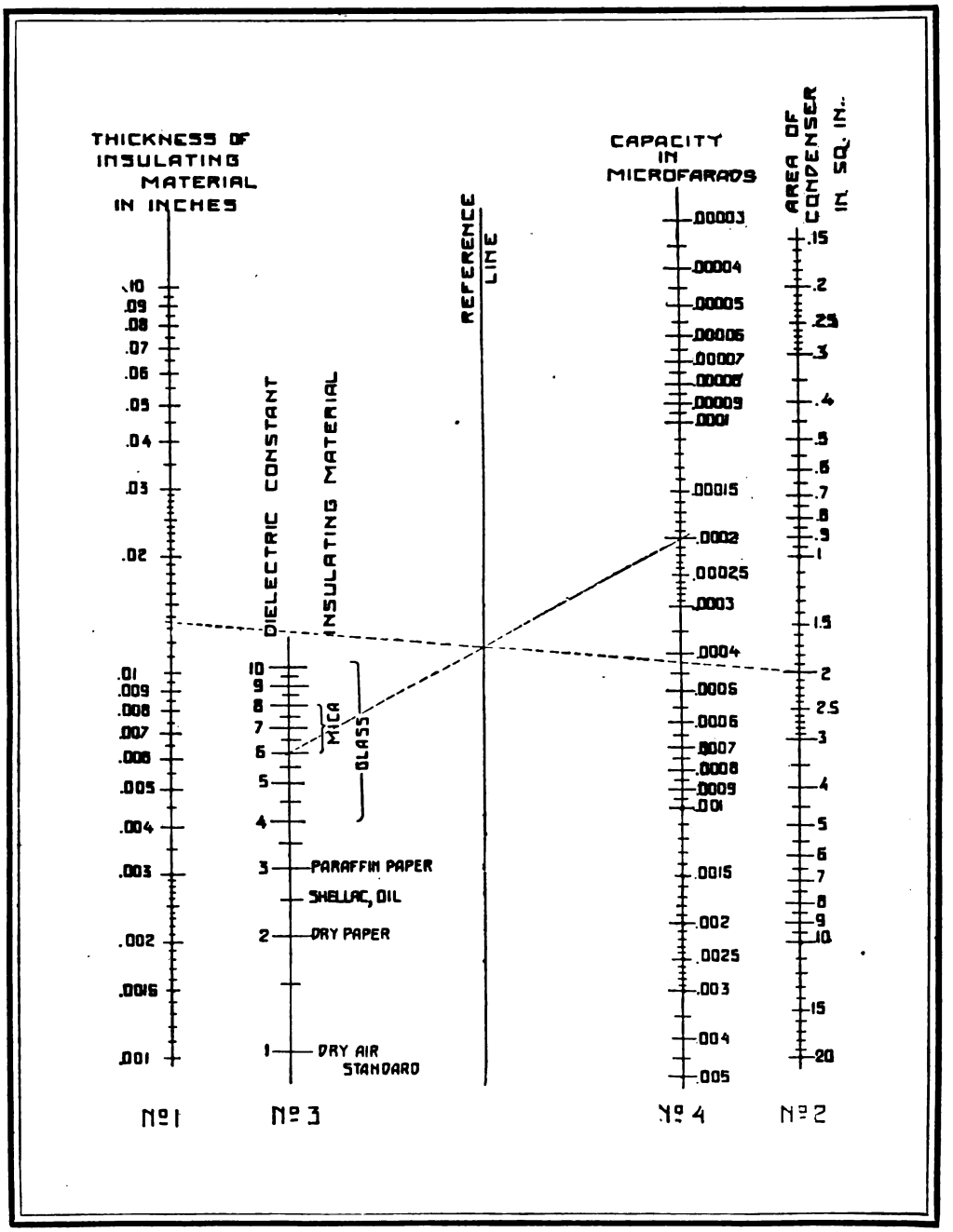

USE A COMMON RULE ON THIS CHART FOR FINDING OUT THE CAPACITY OF YOUR CONDENSER

FIGURE 1: *To obtain a condenser of a certain capacity, connect the value of capacity on scale No. 4 with the dielectric constant for the kind of insulating material you wish to use, on Scale No. 3, with a straight line. Then connect the thickness of the insulating material you want to use (on scale No. 1) with the point where the first line crosses the reference line, and carry this last line over to scale No. 2. This will give you the correct area for the conducting plates.*

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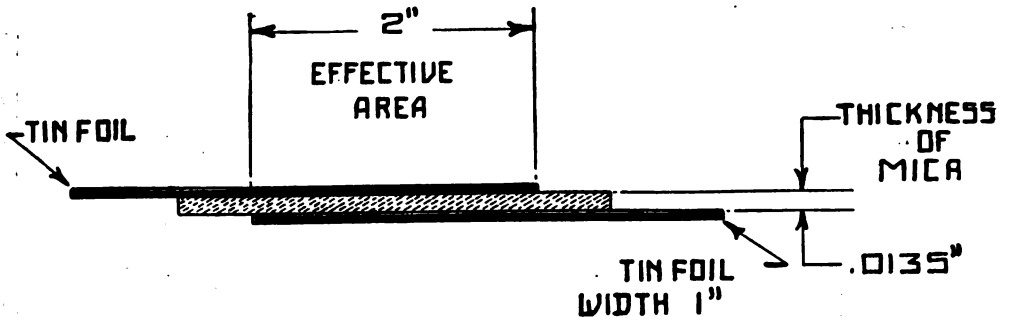

FIGURE 2

This diagram shows how to determine the different dimensions that are necessary to know in using the chart shown in Figure 1, for designing a condenser. Notice that the effective area of the plates is the overlapping area.

Material	*Constant (K.)*
Air (standard)	1
Paper	1.5-2
Paper (Paraffin)	3
Shellac	2.5-3.5
Oil	2.5
Mica	6-8
Glass	4-10

To enable the radio man to determine the capacity of a condenser which is already built, or to determine the size of a condenser which he intends to build that shall have a certain predetermined capacity, the chart in Figure 1 has been prepared, which incorporates the formula given above.

To use the chart to determine the capacity of a condenser, let us consider the example:

A condenser constructed as shown in Figure 2, contains two sheets of tinfoil conductor, which have an effective (overlapping) area of (2 by 1)=2 inches. The thickness of the mica insulator sheet is .0135 inch. Connecting .0135 on scale No. 1, with 2 on scale No. 2, with a ruler, and then connecting the reference point (where this line crosses the reference line) with the dielectric constant for mica (about 6) on scale No. 3 we find the continuation of this line crosses the scale No. 4 at .0002 mfd. which is the capacity of the condenser.

To determine the area of a condenser which will have a certain capacity, the process is reversed.

Example:

To construct a condenser with a capacity of .0002 mfd., using a mica dielectric of .0135 inch thickness, we proceed in the following manner:

Connect, on scale No. 4, the capacity desired (.0002) with the dielectric constant (6) on scale No. 3. Now connect the point of intersection (of this line with the reference line) with the thickness of the dielectric to be used (.0135) and extend this line over to scale 2, which will give the effective (overlapping) area of the plates to be used.

This chart will certainly be a time-saver for the amateur and will give him assurance that he is getting the most out of his experimental circuits by the use of the proper-sized condensers.

Preserve These Hoffman Charts for Reference!

They will save you time and insure accuracy when you build your set. Previous charts have told how to calculate wavelength of antenna circuits, series circuits and circuits in multiple, and how to calculate coil design for obtaining any value of inductance. Following articles will include charts for calculating the characteristics of the antenna, charts for the design of loop antennas, and charts for the design of C. W. transformers.

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Traffic Cops *of* the Ether

How "Daddy" Cadmus Checks Up the Good and the Bad Boys of Radio

The task of keeping tab on wavelengths used by transmitting stations and of running down offenders on one hand and of helping amateurs to tune up their sets and to get a license on the other is taking up more and more time of Uncle Sam's radio inspectors. This article tells how one of them facilitates his duties with his ingenious "radio chariot."

By HENRY M. NEELY

UNCLE SAM is a kind and indulgent relative to all the good little boys in radio. But all of the little boys in radio are not good little boys—and Uncle Sam has to keep a watchful eye on the bad ones to see that they do not interfere with the pleasure of the good ones.

It was hard enough in the past to do this when there were only a few amateur sending stations and when they interfered with other amateurs who were usually skilful enough to tune them out. But with millions of beginners hooking up all sorts of inefficient sets to receive the modern broadcast programs and with the beginners even more inefficient than their sets, the amateur with the transmitting station has to comply strictly with all of the laws that Uncle Sam has made or else the inspector in his district begins to get complaints from the neighbors. Then there is trouble for somebody.

The radio inspectors all over the coun-

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try are getting wrinkled and gray-haired as these complaints come pouring in. Oddly enough, most of these men are old "hard boiled hams" themselves and they agree with the amateur that the fuzzy growl or high-pitched shriek of the dot and dash code is the sweetest music in the world. But they are officials sworn to uphold the law and their personal sympathies have nothing to do with the case. If they find that an amateur against whom complaints have been lodged is exceeding his legal wavelength or is stepping on the gas too hard in the matter of power input or has not even a flirting acquaintance with that charming mystery of radio known as "Logarithmic Decrement," they have to walk in on him, pull back their coat lapel, show their badge and say gruffly, "Will you come quietly or shall I put the bracelets on?"

It remained for the inspector in the Third District to combine his hobby with his duty and thus reduce his worries by about 101½ per cent. Lieut. R. Y. Cadmus, popularly known as "Daddy" Cadmus, lives in Baltimore and has headquarters in the Custom House there. He is the radio daddy of all the good little boys who pound a mean fist from the District of Columbia to Trenton, New Jersey and all over the eastern half of Pennsylvania. The automobile is Cadmus' hobby; checking up on the shortcomings of his numerous radio children is his official duty.

With the rapid growth of amateur stations, he found it a tremendous job to investigate all of the complaints made by the enthusiast of the oatmeal box radiophone against amateur transmitters, because it was necessary to set up a perfectly calibrated receiving set within hearing distance of each station under suspicion. And it is no easy job to shove a wavemeter up against a strange aerial and take your oath as to the accuracy of the result!

Instruments of this kind are heavy and cumbersome to carry around anyhow; the mere problem of transportation is enough to make the average radio inspector quit his job.

So Daddy Cadmus combined his automobiling hobby with his calibrating duty and installed a complete testing station aboard his motor car. This is not a toy by any means, nor is it one of those affairs that are driven around the streets for advertising purposes and that have to be repaired every night to undo the damage done by the jolting of the car during the day.

This station on wheels is built like a battleship so far as concerns what engineers call its "factor of safety." It has a miniature four-wire aerial strung between a steel mast on the front and another steel mast on the back, and these masts themselves are supported and braced by specially fitted steel arms that would almost do for bumpers if Daddy Cadmus should choose to try to push a freight car off the track.

On the back seat of the car is mounted a receiving set with a detector and two stages of audio frequency amplification, using the well-known three honeycomb coil circuit for tuning with variable condensers in each circuit.

When he first made this set Daddy Cadmus took it out in the country outside of Baltimore and experimented with it just to see whether it would be possible to get long wavelengths on such a short aerial. He was gratified to find that the big transatlantic stations came in like a ton of bricks on 20,000 meters with the use of 1,500-turn coils.

He then plugged in on the little baby outfits and found that he could get the amateurs; in this way he knew that he had a set that was good for his purpose. It was then merely a matter of placing a wavemeter in resonance and from then on he could read off the wavelengths of any station with a margin of accuracy that was astonishingly minute.

As soon as he had proved the success of his experiment he and his assistant, L. E. Richwien, of Baltimore (who in

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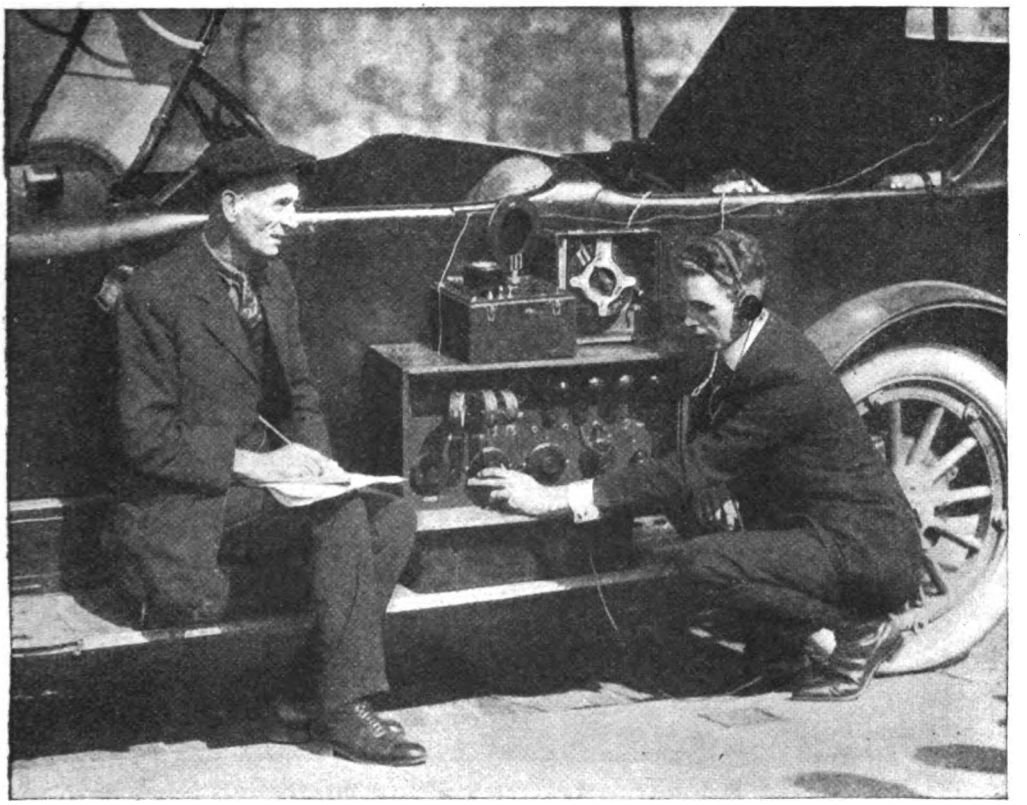

HUNTING OVERGROWN WAVELENGTHS

By means of this portable apparatus, Inspector R. Y. Cadmus and his assistant, L. E. Richwien (3XT) traveled about in the Third District and in a little over two weeks checked up as many stations as would normally occupy their time for ten times that period.

his unofficial moments signs off "QTC nil nw OM 73 CUL GN de 3XT"), started on an inspection tour to see how much ground they could cover. There are not many so called "efficiency experts" in business houses who can point to such a saving of time.

With this traveling station, Daddy Cadmus and Richwien checked up, in a little over two weeks, as many stations as they had been able to check up in between five and six months without it.

Cadmus admits that he did not observe union hours on this expedition. The two men spent their days flying from one station to another, personally inspecting each bit of apparatus; and they spent their nights at some advantageous locality outside of different cities listening in on all of the DX work and all of the plain key pounding going on in the ether about them.

First Richwien would put the receiving set and the wave meter on the running board and wear the phones while Daddy Cadmus stole a few hours' sleep on the back seat; then Daddy Cadmus would relieve him and Richwien would take the inspector's place among the blankets. In seventeen days these two men managed to spend three nights of sleep in their own beds at home.

Who wants to be a radio inspector now?

Although it has nothing to do with this traveling check-up station, Daddy Cadmus had some things to say about radio in general when I saw him on this trip.

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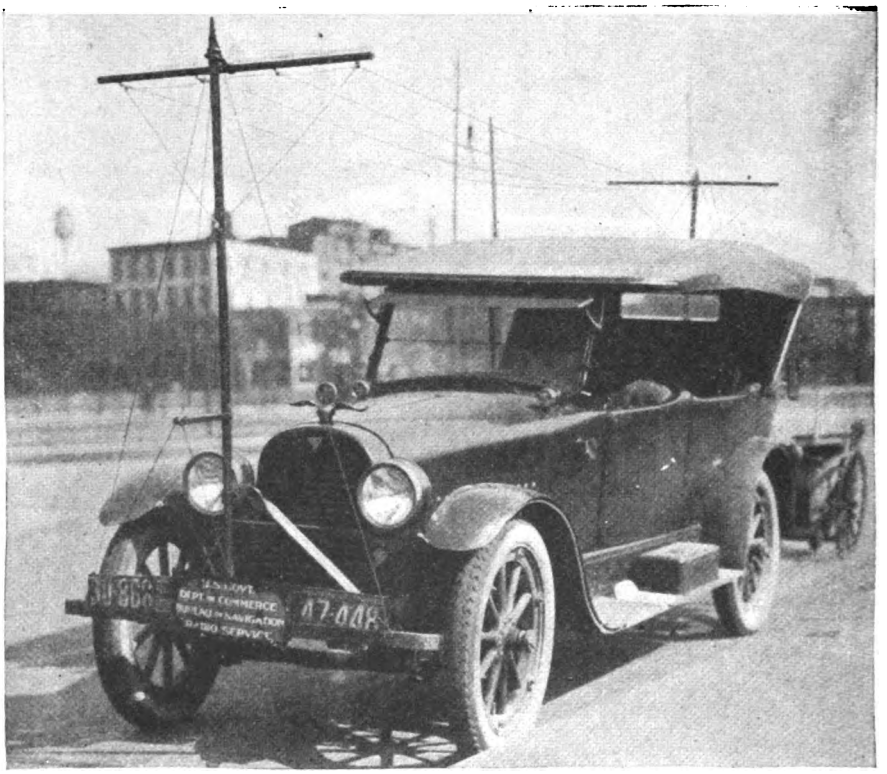

THE RADIO SLEUTH ON THE TRAIL

With this essentially serviceable antenna system, the Inspector is enabled to pick up signals from transmitting stations ranging from the greatest transatlantic giants to the smallest of the amateur pygmies.

"Nobody can realize," he said, "the condition of chaos in an inspector's office with the present radio bill still pending before Congress. Every license that we issue now is for three months only and is marked *provisional* because nobody knows what Congress is going to do in the matter of technical requirements for transmitting stations and we cannot give a regular two-year license until the details are determined upon. Consequently we have been giving licenses good for only three months. This would not be so bad if we were permitted at the end of that time merely to write the word *Extended* across the face of the license. But we are not. We must forward new application blanks to each station and each station must go through all of the detail of filling out a complete description of its set, in duplicate, while we have to go all through once more the process of entering and filing and taking the oath and stamping and everything connected with the issuing of a new license. This applies not only to the amateur stations but to the broadcasting stations as well, so you can imagine the kind of job we have. In my district alone there are three clerks who have to work overtime every day on nothing but this matter of licenses.

"The past few months, remarkably enough, have shown a decrease of something like 40 per cent in the number of amateur transmitting stations that have applied for licenses, either new ones or renewals. This might seem to indicate that the interest in radio is dying out but my investigations show that the very contrary condition is the cause of it.

"Prior to a year ago, Sonny could lock

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himself up in his own room and spend the whole night in perfect bliss 'chewing the fat' with his fellow hams within hearing distance of his spark gap. Father was probably away at the club and Mother was in the kitchen washing the dinner dishes and Sister was probably fox-trotting around the parlor with a dude in a high collar just home from college.

"But is Sonny allowed to have any such joyous evenings by himself these days? He is not.

"As soon as the good radio weather came in in the fall, Father stayed home from the club and Mother let the dinner dishes go until next morning and Sister brought the dude upstairs and introduced him to the family and the whole crowd took Sonny's favorite chairs in Sonny's room and insisted on Sonny tuning in on the nearest 360-meter broadcasting station and putting it on the loudspeaker. By the time the concert was over it was time for Sonny and everybody else to go to bed.

"Then they heard about improvements that could be put on these receiving sets and they had to have radio frequency and audio frequency amplification and the money that Sonny might have put in a new motor generator or a 500-cycle rotary gap went for apparatus that would make enough noise so that "Uncle," two blocks away, could hear the howling of the oscillating bulbs even if he could not make out any of the music.

"After about six months of this, Sonny simply shuts down his set in disgust because Father and Mother and Sister and the high-collared dude have all learned to twist the knobs, and Sonny is lucky if he is allowed in the room at all. Consequently when his transmitting license expires it is not worth while for him to apply for a renewal. All of the apparatus in his old set has gotten rusty or is falling apart and the money that he might have used to repair it has been spent on the family receiving set."

That does not sound as if Daddy Cadmus' idea of a perfect evening was listening to a broadcast concert, does it? Well it is not.

Daddy Cadmus is a "hard-boiled ham" himself and there is no music in the world to him quite so sweet as a good, clean fist, shooting code at something like 25 to 30 words a minute on a 500-cycle note.

Maybe that is an old-fashioned view to take of radio but there are a lot of us old timers, fast dwindling into a pathetic minority, who still feel that way about it.

How to Use Your Radio Set on Your Vacation

In the next number of Popular Radio *Mr. William F. Crosby will tell in specific and helpful detail just how to rig up your receiver in your camp by the water or in the woods, and how to install it on your motor car. The author is one of the most experienced men in the country on installations of this kind, and his article will be fully illustrated not only with numerous hook-up diagrams but also with photographs of actual—and successful—vacation sets in practical use.*

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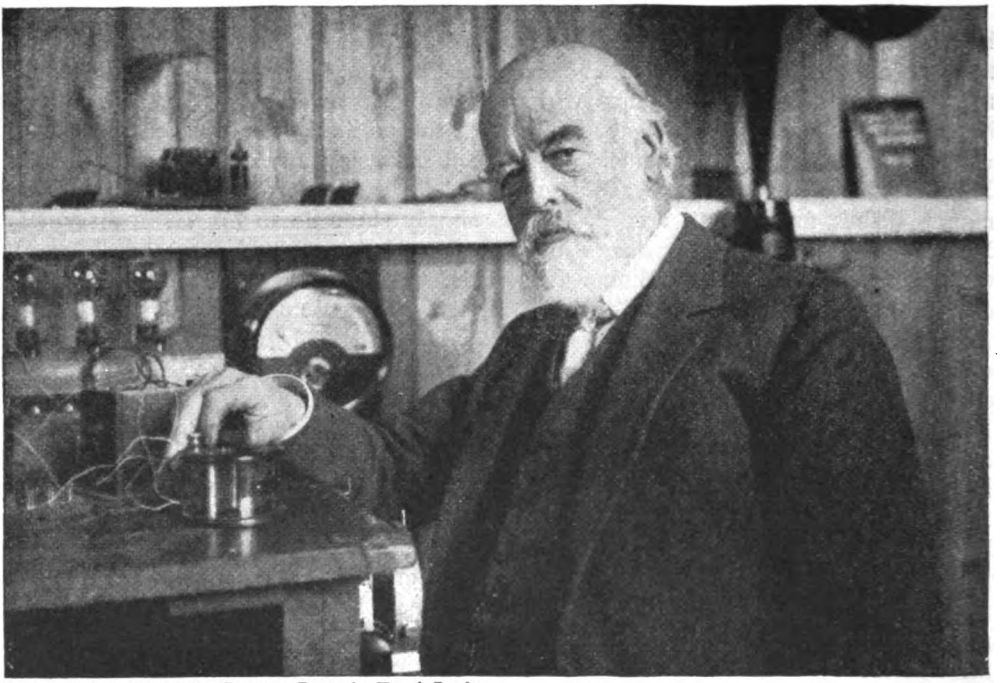

From a photograph made for POPULAR RADIO by Hoppé, London

A SCIENTIST WHO DEMONSTRATES HIS THEORIES BY PRACTICAL EXPERIMENT

The importance of coils in both receiving and transmitting sets can hardly be overestimated. In this article the distinguished English scientist, Sir Oliver Lodge, gives the results of his laboratory investigations that are of incalculable value to the radio amateur.

HOW TO GET THE MAXIMUM INDUCTANCE IN YOUR COILS

Third of a Series of Articles Written for POPULAR RADIO by—

SIR OLIVER LODGE, F.R.S., D.Sc., LL.D.

THE conditions under which a coil can have maximum self-induction (inductance) for a given length of wire seem to have been laid down by the great mathematician Gauss, in or about 1865, but in what form that can have been then done I do not know. Anyhow, Clerk Maxwell, in his great treatise published in 1873 gives a number of complete formulas for inductance, and clearly specifies the condition for its maximum. He evidently paid great attention to the subject of mutual and self-inductance, probably in connection with his determination of the absolute value of the ohm (or "British Association Unit," as it used to be called then).

The first condition is that the winding should be as compact as possible, so as to bring every part of the wire as close as possible to every other part, so that as many as possible of the lines of force, due to each, may thread the others. That will be achieved by making the cross section of the winding on the coil either round or square, not oval or oblong. That much is obvious, because that is the most compact shape: but it is not at all

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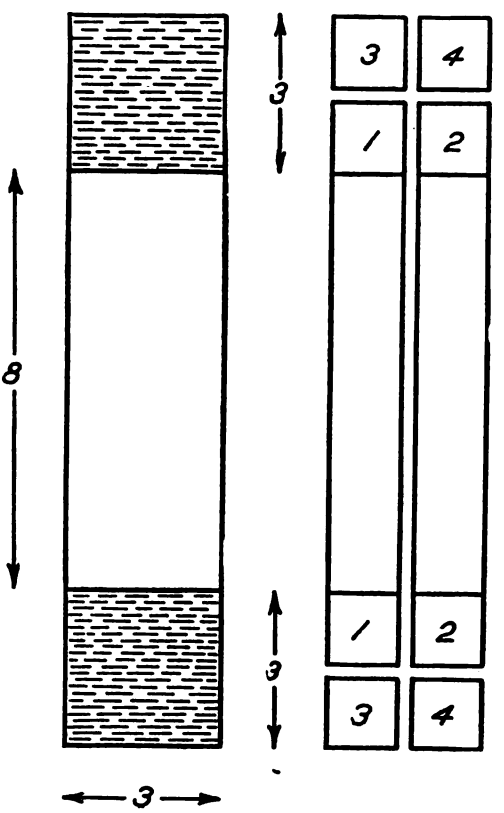
obvious how big the diameter of the coil should be in proportion to the size of the channel which contains the winding. That is what has to be worked out mathematically.

Although the working out may be considered complex, the result can be stated with great ease. Taking the channel for the wire as square, the outside diameter of the coil must bear, to the inside diameter, the ratio 47/27, which for all practical purposes is the same as 7/4, or 1¾. Hence the shape of the coil which gives maximum self-induction is as drawn to scale in the diagram (Figure 1), the breadth and depth of the winding being 3, the internal diameter 8, and the external diameter 14. For the present, we may take that as granted; and in this shape, no matter whether the turns are packed close together or not, the coils employed in radio ought to be wound (though they seldom are). That is the best and most efficient shape; and by adhering to this shape—other things being equal—the deleterious capacity and resistance in the coil are reduced to a minimum.

It need not be supposed that the shape must be very *precisely* adhered to. It is a common property of maximums and minimums that a slight fluctuation on either side makes but a small difference. This shape is the ideal to aim at, but some variation is allowable.

For instance, suppose (having made one coil), we want to put another alongside of it, and in series with it; the inductance will be immensely increased by an amount which is quite well known if the positions are given. But the shape will no longer be the best. Still, the difference is not very important; and something like the best shape can be restored by having four coils instead of two, and putting them in pairs side by side, with one pair big enough to fit over the other, as indicated in the diagram (Figure 1). Numbering the four coils 1, 2, 3, 4, it will be best to connect them together in that order, so that the extremities of the wire, at which the greatest difference of potential will occur, are as far separated from each other as possible. The connection 1, 2, 4/3, or 1, 3, 4, 2, is slightly less desirable.

The effect of putting one coil outside of another, instead of side by side, is that the mean radius of the whole winding is increased somewhat: otherwise the expression for the inductance is the same in the two cases. It is as broad as it is long, so to speak. Or rather, whether the length exceeds the breadth, or the breadth exceeds the length, makes no difference. That is not obvious, but so it



THE BEST SHAPE FOR COILS

FIGURE 1—*At the left is shown the dimensions for a single coil; at the right is shown the arrangement of a number of coils that can be connected in series, and that will still keep the best shape for inductance. For maximum results and to insure the lowest distributed capacity they should be connected as they are numbered: 1, 2, 3, 4.*

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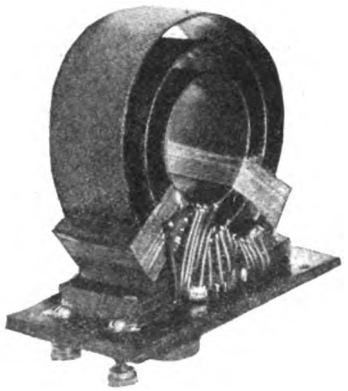

A THREE-LAYER COIL

This coil is tapped so that various inductance values may be used to facilitate changes in wavelengths ranging from 150 meters up to 3,000 meters. It will be noticed that this coil complies rather closely with the maximum inductance conditions so far as its shape is concerned.

A FIGURE-EIGHT COIL

This special type of coil has the wires run in the form of a figure eight. It is usually used in cases when some form of loosely coupled coil is suitable. The coupling between two such coils may be varied by simply revolving one of them upon its axis throughout a revolution of ninety degrees.

A HONEYCOMB COIL

This coil, which is widely used here in America, adheres closely to the ideal for maximum inductance. With this type of apparatus it is easy to obtain fairly close coupling by placing two coils side by side. The coupling is varied merely by drawing the coils farther apart.

comes out from the formula, which is symmetrical as regards length and breadth of cross section.

The advantage of a combination of coils, like this, is that it enables the wavelength to be easily changed; that is to say, it enables a coil to be selected which shall give approximately the order of wavelength required, fine adjustments being done by means of supplementary variable condensers, or by a separate variable inductance, or both. But we will not trouble about these tuning details, which are quite well known and understood.

Although I have emphasized the value of a maximum inductance shape, such considerations must not be allowed to override practical convenience; and, instead of packing coils into a square section, it is usually much more convenient

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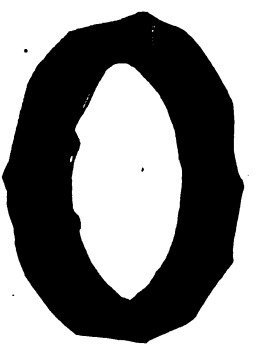
A TRANSMITTING HELIX

This type of coil is made of edgewise-wound copper strip instead of wire. The coil is held in shape by means of insulating spacer-rods which are slotted to fit the copper strip. The main advantage of this form of coil for transmitting lies in the large conductive surface area which is offered to the passing currents.

A BANK-WOUND COIL

In this coil the litzendracht wire is wound around a sort of circular ladder. This formation eliminates a large amount of useless insulating material from within the magnetic field of the winding, and cuts down the "hysterisis" losses in the insulation.



ANOTHER FORM OF MULTIPLE-LAYER COIL

Each layer of the winding of this coil is separated from the next consecutive layer by a snake-like layer of wire which is interposed between the main layers. All of the wire in the coil is connected in the circuit, however, which makes this coil exceptionally efficient.

to arrange them either side by side, or one outside the other. That is to say, to arrange them so as to form either a cylinder or a disc. And again, such an arrangement *has* an advantage; for, though the inductance will be less than it might be with a given length of wire, the terminals are thereby kept far apart, and the capacity is therefore also diminished. Hence I do not propose to consider any arrangement except one or other of these plans for the construction of multiple coils.

When we are dealing with the single coil, however, there is no question but that the best shape is as stated before, that is to say, one with an external diameter of 14, and an internal diameter of 8.

Further details about this we will consider in a succeeding article.

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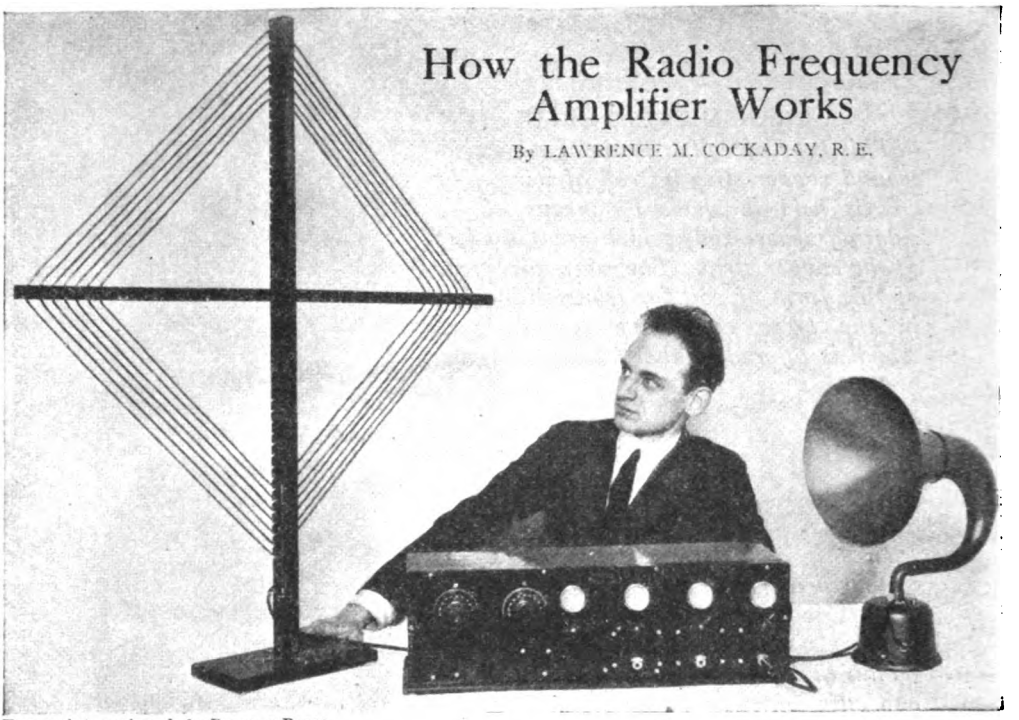
How the Radio Frequency Amplifier Works

By LAWRENCE M. COCKADAY, R. E.



From a photograph made for POPULAR RADIO

SIMPLE "HOW" ARTICLES FOR THE BEGINNER—No. 9

A beginner's first vacuum tube set usually includes simply a tuner and one vacuum tube as a detector. When he has mastered this set, his next thoughts are directed toward methods for amplifying the received signals; at this point it is always a question in his mind whether to use radio or audio frequency amplification. This article (see also "How the Audio Frequency Amplifier Works" in POPULAR RADIO *for February, 1923) tells not only how the two methods work but also their particular uses and advantages.*

IN the last article of this series we stated that cascade amplification of radio signals could be divided into two classes, as follows:

First, audio frequency amplification.

Second, radio frequency amplification.

Audio frequency amplification is cascade amplification of the rectified impulses which are flowing in the plate circuit of the detector tube. These impulses are of an audible frequency and the successive stages of amplification are coupled together with "audio frequency amplifying transformers," which step up the voltage of the audio frequency impulses and supply them to the grid circuit of the next tube.

Radio frequency amplification is cascade amplification of the impulses of radio frequency current received from the antenna circuit of a receiver before they have been rectified by the detector tube. The successive stages are coupled together with radio frequency transformers.

In the article "How the Audio Frequency Amplifier Works" in the February issue of this magazine, we studied the functioning of this type of apparatus fairly thoroughly; those readers who have read this article should understand its fundamentals clearly.

Before we take up the subject of how the radio frequency amplifier works, however, let us learn of one of the disadvantages of audio frequency amplification.

The detector tube receives radio fre-

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quency oscillations and turns them into pulses of direct current. But *the impulses must be of a certain strength before the detector will respond to them.*

Let us consider the case of a receiving set that employs a vacuum tube detector and two stages of audio frequency amplification. The set is installed in a city. Signals from stations located in the city were detected and received with such volume as to be unbearable. This is because the detector delivered a fairly large impulse to the amplifiers and they further strengthened them to an enormous value. Signals from stations, say 500 miles away, were only just audible with the detector alone, but when the amplifiers were used they were comfortably audible; the amplifiers took the feeble current from the detector and strengthened it. Signals from across the other side of the country, however, were too weak to be detected by the detector tube and so the amplifiers were supplied with no current; thus no signal was heard.

This difficulty of the audio amplifier may be summed up in the following statement.

The audio frequency amplifier will not function on a signal unless the signal is of sufficient strength to operate the detector tube and thus supply an audio impulse to the amplifier. This is true no matter how many stages of amplification are used. Audio frequency amplification has its use, however, as it is the most efficient method for getting a loud signal when the initial signal is strong enough to operate the detector tube.

Radio frequency, on the other hand, has just the opposite characteristics; by its use, weak distant signals are amplified, but they cannot be increased by this method to a value strong enough to operate a loudspeaker satisfactorily. Radio frequency amplification strengthens the feeble oscillations received from the antenna circuit until they are strong enough to be detected by the vacuum tube detector.

In other words radio frequency amplification takes place *before* the signals are rectified by the detector and audio frequency amplification takes place *after* they are so rectified.

So much for the general explanation. Let us now see how the radio amplifier works.

In the diagram (Figure 1) is shown a conventional circuit with two stages of radio frequency amplification, and a vacuum tube detector, that employs a loop antenna. The tuning elements consist of the loop inductance and the variable condenser VC. The first stage of amplification consists of the tube V1; this is coupled to the second stage tube V2 by means of the radio frequency amplifying transformer T1. The second stage is coupled to the detector tube V3 by means of a second transformer T2, which is started by a condenser VC_2, and which supplies the amplified radio frequency impulses to the detector tube for rectification.

A weak impulse (much too feeble to operate a detector tube, let us say) is received by the loop and tuned by the condenser VCI. This high frequency impulse flows through the input circuit I and impresses a tiny voltage wave A on the grid of the amplifier tube V1. The relay action of the tube reproduces this wave form in its plate circuit II and causes a current B to flow through the primary winding of the transformer T1. (This type of transformer is unlike the audio frequency transformer in that it has an air core and readily passes high frequency currents through its windings, whereas the audio transformer has an iron core and passes only low frequency currents.) The voltage of the impulses is stepped up by the transformer T1, and supplied by its secondary winding to the grid of the tube V2 in circuit No. III. This voltage is shown at A′; by comparison with A it will be seen that it has been increased considerably. The tube V2 then responds to this voltage A′ and a current wave B′ flows in its plate circuit IV, through the primary winding

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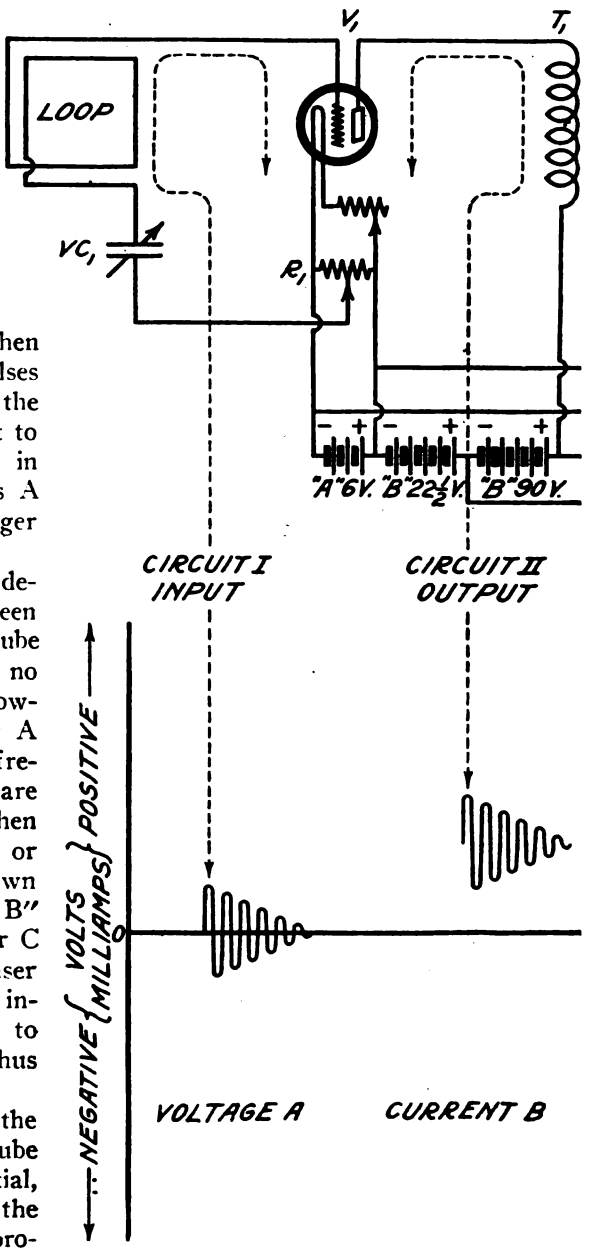
FIGURE 1

This diagram and chart show how the successive stages of amplification increase the minute voltages and currents of radio frequency energy until even the weakest signals are reinforced enough to be detected by the vacuum tube detector. This amplification is done BEFORE *the signals are detected.*



of the transformer T2. Comparison of B and B¹ will show a great increase in the current value. The transformer T2 then steps up the voltage of the impulses and impresses a voltage A″ on the grid condenser GC which passes it to the grid of the detector tube V3 in circuit No. V. Compare Voltages A and A″. A″ is very much stronger than A.

If A had been supplied to the detector tube direct, it would have been too weak to be detected by the tube V3 and there would have been no response in the plate circuit VI. However, the weak impulses shown at A have been amplified by the radio frequency amplifier until they are strengthened as shown at A″, when the tube V3 is able to detect them, or in other words, rectify them as shown at B″ in circuit VI. This current B″ flows through the bypass condenser C and the voltages on the condenser cause a low frequency current, as indicated by the dotted lines in B″, to flow through the telephones T thus producing audible sounds.

It must be borne in mind that the impulses on the grid of each tube oscillate about its free grid potential, and to secure maximum results the potentiometers R1 and R2 are provided as means for adjusting this free grid potential with respect to the filament.

By means of radio frequency amplification, then, distant signals may be easily heard without the use of audio frequency amplifiers, that could never be heard with any number of stages of audio frequency amplification if radio frequency amplification were *not* used to strengthen them.

This same sensitivity of the radio frequency amplifier makes it suitable for use with the loop antenna, which collects only an extremely small amount of energy, where the audio frequency amplifier *alone* would fail.

The use of radio frequency amplifica-

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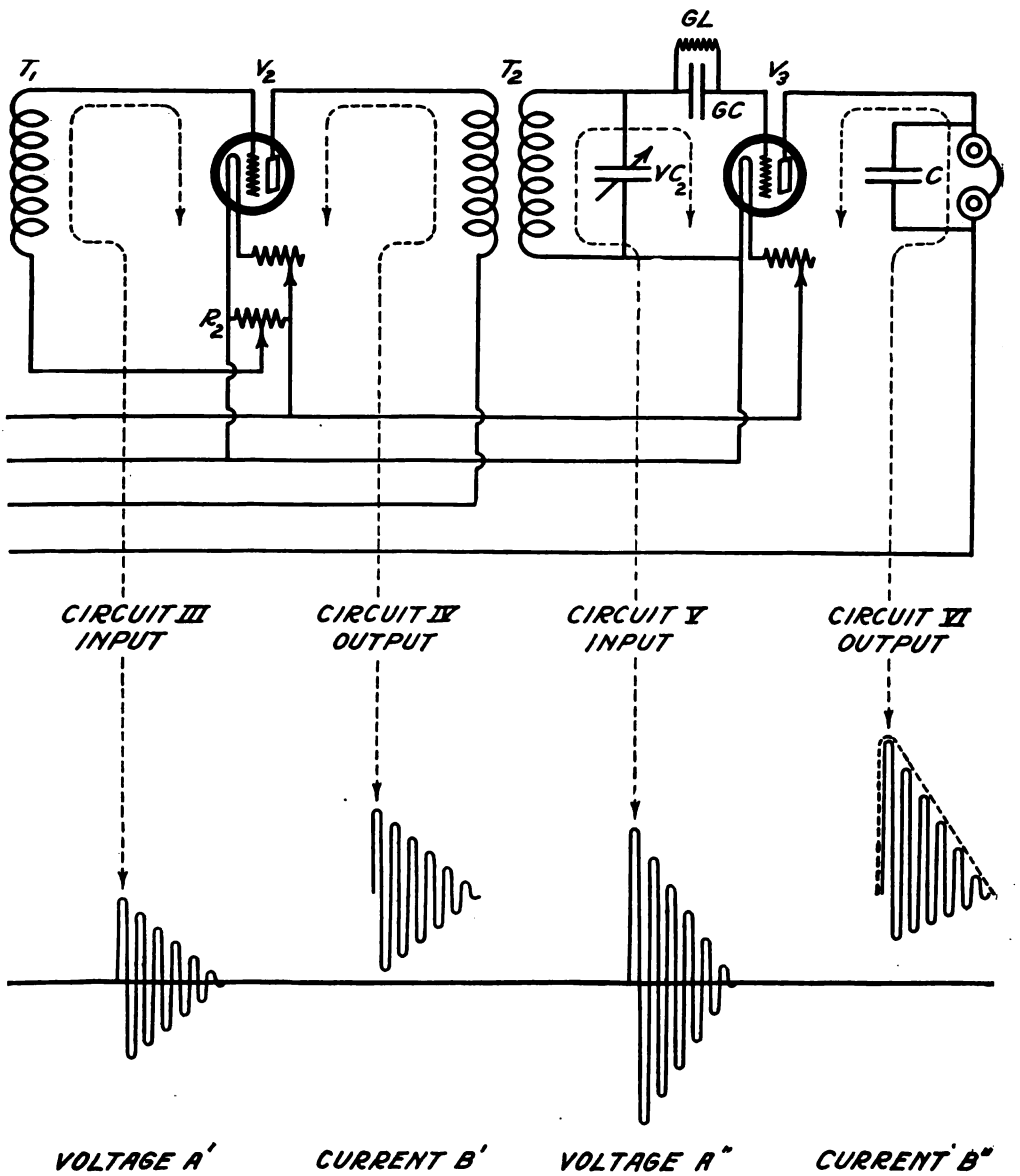

tion with a loop antenna for building up the strength of the feeble impulses so that the detector tubes can detect them, combined with the use of the audio frequency amplifier to increase these audible impulses to sufficient strength to operate a loudspeaker, makes an ideal set for listening to broadcasting. And not the least of its virtues is the fact that it may be assembled complete in a case similar to that of a phonograph, with batteries, tubes, loop and all; no outside connections are necessary.

In summing up, the use of audio frequency amplification is limited to signals which are strong enough to be detected, when this method will increase the volume tremendously. The use of radio frequency amplification is for increasing the strength of feeble impulses that are not strong enough for a detector to pick up alone.

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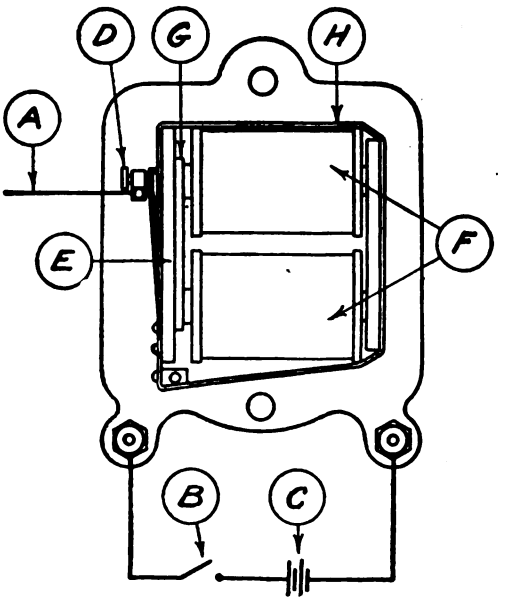
THE PARTS OF THE BUZZER TEST ARE—

A is the wire that should be connected to the ground wire of the receiving set; B is a simple push button switch; C is a couple of dry batteries; D is the adjusting set screw; E is the armature; F shows the magnets; G is a small piece of cardboard, and H is a rubber band.



How to Make a Simple Buzzer Test at Home

By RICHARD LORD

THE amateur who has had trouble with his crystal detector will welcome this word of practical advice from an experienced New Jersey fan; it tells how the trouble can be eliminated:

Aside from the fact that the buzzer test aids the amateur considerably in locating sensitive spots on a crystal, it is a real help in preventing the fading out of signals; merely by pressing the test buzzer switch the signals may be brought back to their former strength. One theory offered in explanation of this phenomenon is that a slight film of oxidation forms between the cat-whisker and the crystal, thereby reducing the strength of the signal. The pulsations of current from the test buzzer seem to break down this film and to permit better contact.

For the dyed-in-the-wool fan who must have the best of everything, there is on the market a high frequency buzzer which gives an especially clear, even, and pleasing note in the phones. However, the cost of this buzzer is beyond the reach of some of us; for these an ordinary buzzer can be made to serve admirably. A piece of cardboard or folded paper placed between the heavy iron armature and the contact spring (as shown in the diagram on this page) produces a fairly high and even tone. A rubber band placed as indicated in the diagram will also be found advantageous in obtaining a high note. After the buzzer is obtained it is connected in series with some kind of a switch, and one or two dry cells. One of the most convenient switches, in the writer's estimation, is nothing more than a simple electric push button.

An examination of the buzzer discloses a little adjustable screw, which makes contact with the vibrating armature. To this one end of a wire is fastened; the other end is connected to the ground wire of the receiving set. In some types of loose-coupled sets it will be found that this type of connection will not give satisfactory results; if such is the case, connect the latter end of the wire directly to one side of the detector, rather than to the ground lead. This connection will invariably work.

It is advisable to place the buzzer in a small box, so as to eliminate mechanical noises as far as possible. Fill the box half full of absorbent cotton and place the buzzer on this cotton. Then fill the box entirely full of cotton and put the cover on, leaving, of course, the leads projecting out. This box may then be suspended from under the table; it will be found practically impossible to hear the buzzer while in operation.

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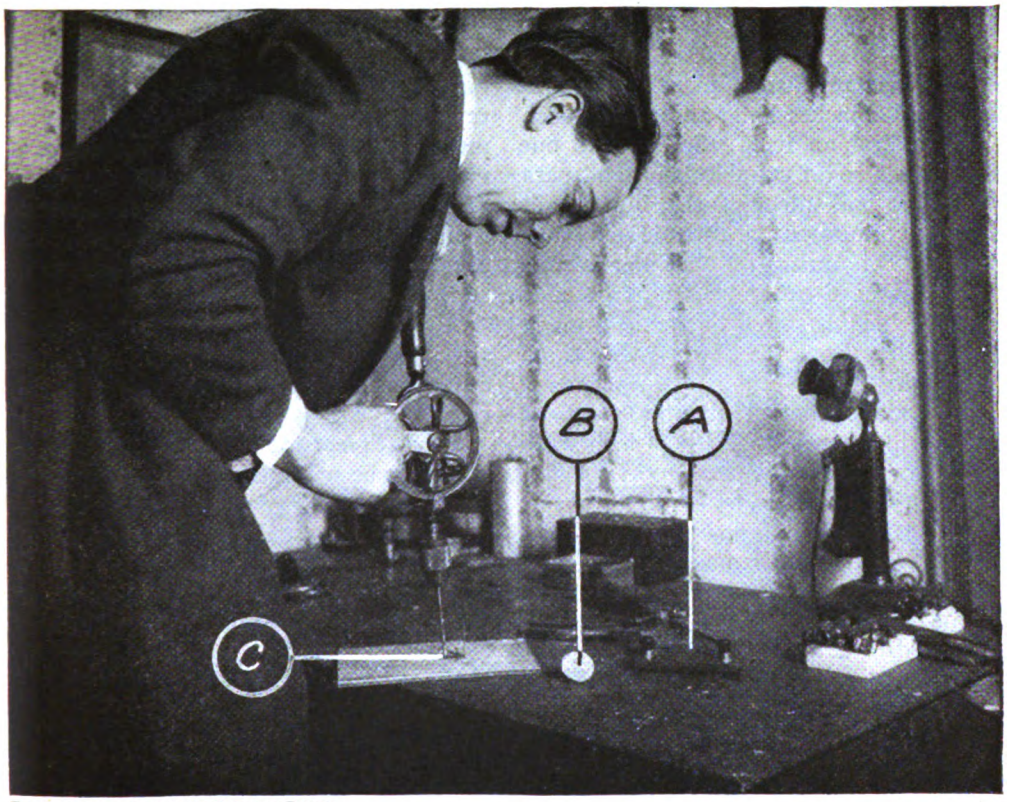

From a photograph made for POPULAR RADIO

This detector with a light spring adjustment, which uses either galena or iron pyrites, consists of (A) the base and adjusting arm, (B) the cup which holds the crystal, and (C) the upright upon which the cup is mounted.

How to Make a Light-Contact Detector

By LEROY WESTERN

EVERY true experimenter in radio at some time or other has used a crystal detector, for as a beginner he started out with a crystal receiving set. Those who are now starting out on their radio experiments will be interested in the detector here described; the time spent in its construction will be fully compensated for by the ease with which it may be adjusted.

The first consideration is the crystal. There are many kinds which can be used in connection with this detector, such as galena, iron pyrites (ferron) and silicon, to mention but a few. Galena is probably the best known and the most frequently used, but a little experimenting will show the amateur that some of the others are just as good, certain ones in some ways better. For instance, sensitive specimens of iron pyrites, while considerably more difficult to find than sensitive galena, give equal results and retain their sensitiveness for a long period of time. This crystal is generally used with a stiff phosphor bronze spring, the end of which is pointed.

In the construction of the detector first select a base of hard wood, or better still, hard rubber or bakelite, 4 inches long by 2½ inches wide. Drill four holes in this base, as shown in the diagram. Get a brass ball ¼ inch in diameter; drill a hole through the center of it which

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will make a snug fit for a ⅛-inch brass rod. Next procure a piece of ⅛-inch brass rod 2 inches long, and thread each end for half an inch. Screw onto one end of this rod a suitable knob and pass the other end through the brass ball. Screw two nuts on the threaded end and fasten a coil spring of phosphor-bronze wire between them as shown. A standard for holding the ball is then made of brass in the form of a square U as indicated.

Now make another standard from a brass strip ⅛ inch thick by ½ inch wide in the form of an L to support the detector cup.

For the detector cup obtain a brass cup, 1¾ inches in diameter, either with or without a mounting screw. If the cup has no mounting screw it will be necessary to drill a hole in the center of the cup and pass the screw through it. A quantity of soft metal for mounting the crystal may be made by dissolving as much tin foil as possible in one ounce of mercury. Knead the mass together thoroughly and heat. When it becomes molten, pour it into the cup and press several crystals of various kinds into its surface.

It is important not to heat the metal any more than is necessary to melt it, as otherwise injury to the crystals may result.

Several pieces of various kinds of mineral may be mounted in the detector cup and their various receiving qualities thoroughly tested against each other. A phosphor-bronze wire spring will serve for most types of crystal, but a gold wire is superior as its point will not easily oxidize.

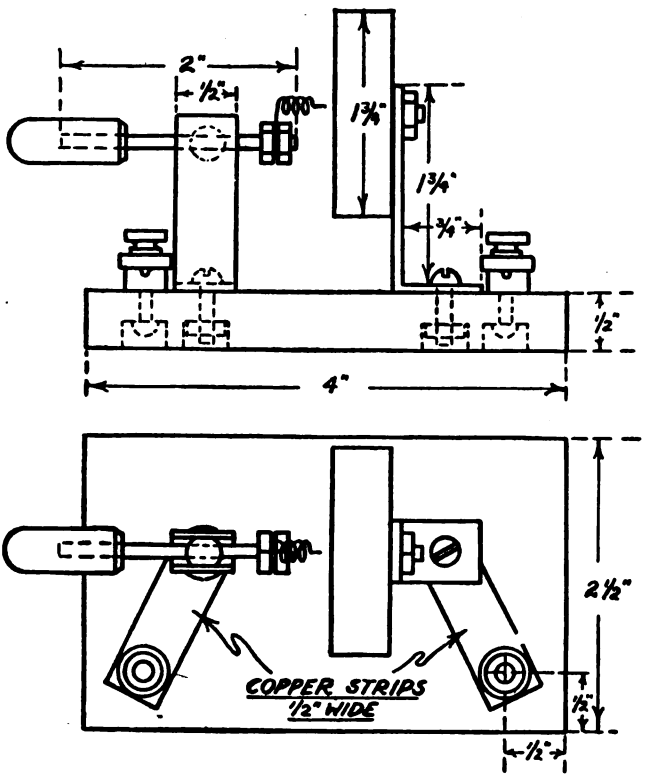

FIGURE 1

This diagram gives the side view (at top) and the top view (at bottom), together with the dimensions of parts of the detector.

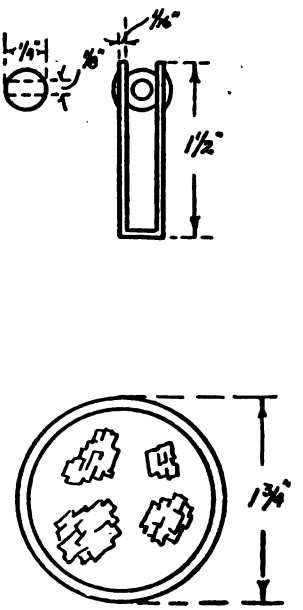

FIGURE 2

This diagram shows the dimensions for the universal joint of the adjustment arm (at top) and the manner of mounting the crystals (at bottom).

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¶ I consider this Four-Circuit Tuner the most important contribution to the equipment of the radio amateur since the invention of the Super-Regenerative Set.

—EDITOR

From a photograph made for POPULAR RADIO

The set as it appears in actual use—small enough to keep in a bureau drawer. The demonstrator is the inventor, Laurence M. Cockaday (2XK).

HOW TO BUILD THE NEW

FOUR-CIRCUIT TUNER

A new and unusual development in vacuum tube control circuits that is exceedingly selective, simple to operate, highly sensitive (it has a verified C. W. range of 3,200 miles and a telephone range of 2,400 miles)—and that CAN BE BUILT FOR LESS THAN $40.00!

BY THE TECHNICAL EDITOR

THE ideal receiving set should have the following five qualifications if it is to meet the needs of the discriminating radio amateur:

A—absolute elimination of interference;

B—unlimited distance range;

C—ease of tuning;

D—truthful reproduction;

E—low cost.

A, B, and C are dependent upon the method of tuning used and the system of

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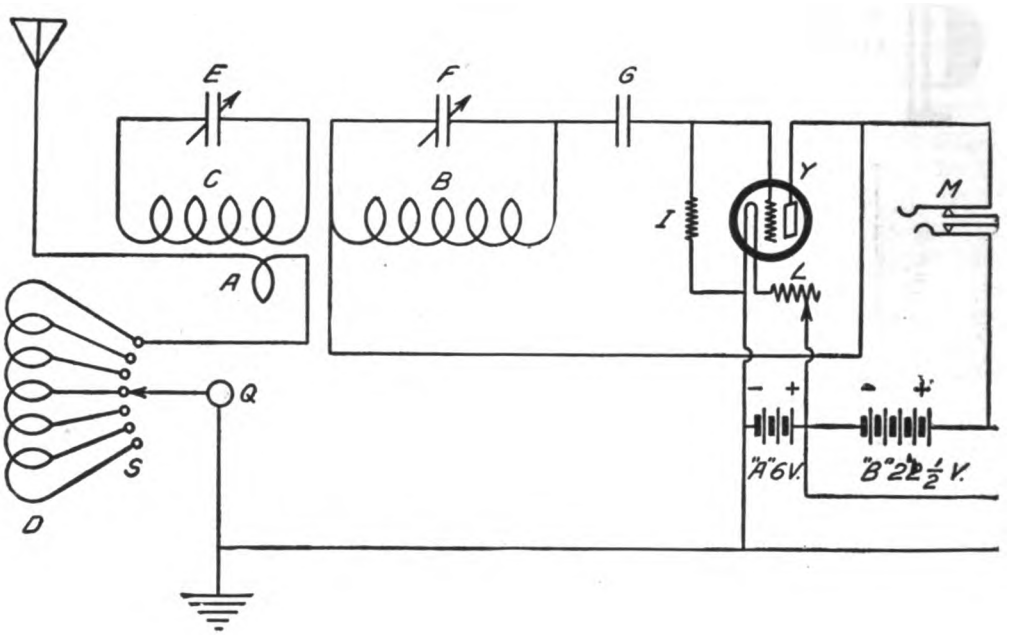

detection. D and E depend more closely upon the type of amplification that is used.

In designing this set we have had these goals in view.

First, therefore, we have determined to use extremely loose coupling to insure the quality A; looser, in fact, than used in any other type of receiver. The step-up voltage ratio of the receiving transformer is 65 to 1. This insures an extremely high grid voltage even from weak signals.

Second, to insure a maximum distance range, and at the same time secure simplicity of tuning, and to hold the cost of construction to a minimum, we have decided to use the regenerative method of amplification as the closest approach to the ideal yet disclosed.

The main shortcomings of the standard regenerative circuit are well known; they may be summarized as follows:

a. A change in wavelength makes necessary a change in the regenerative control to keep the regeneration at a maximum.
b. It is extremely difficult to keep the circuits "stable," so that they will stay at the maximum amplification point. This is due to the fact that changes in the constants in the antenna circuit react on the grid circuit and throw the circuits in and out of resonance so that they oscillate for a few seconds and then cease, causing signals to come in strong for a while and then to die out, and also causing squealing at intervals.

Third, therefore, we have chosen a more simple method for controlling regeneration; it consists of an inductively-coupled stabilizer circuit whose function it is to vary the effective A. C. resistance of the grid circuit of our tuner. This circuit is electrically isolated from all the other circuits in the receiver, but it is placed directly within the magnetic field surrounding the grid coil. It consists of a low-resistance coil shunted by a variable condenser which when it is rotated varies the reaction between the grid circuit and its own circuit.

It is well known that the vacuum tube in a circuit will produce sustained oscillations when the negative resistance of the system equals the positive resistance of the system. The standard regenerator accomplishes this result by varying the negative resistance upward to the correct value.

This new circuit we have evolved, however, accomplishes the result by varying the positive resistance, downward, to the correct value. In the new method

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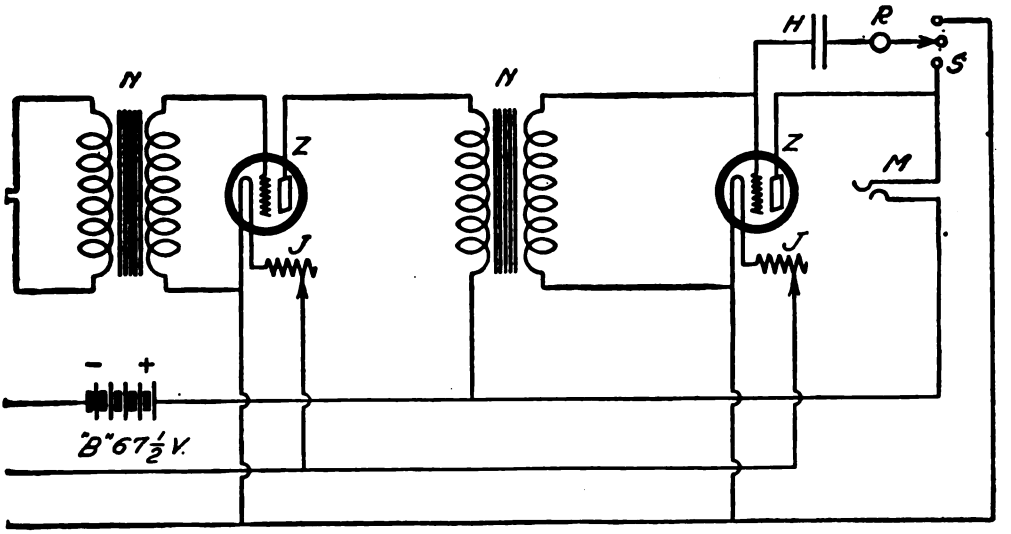
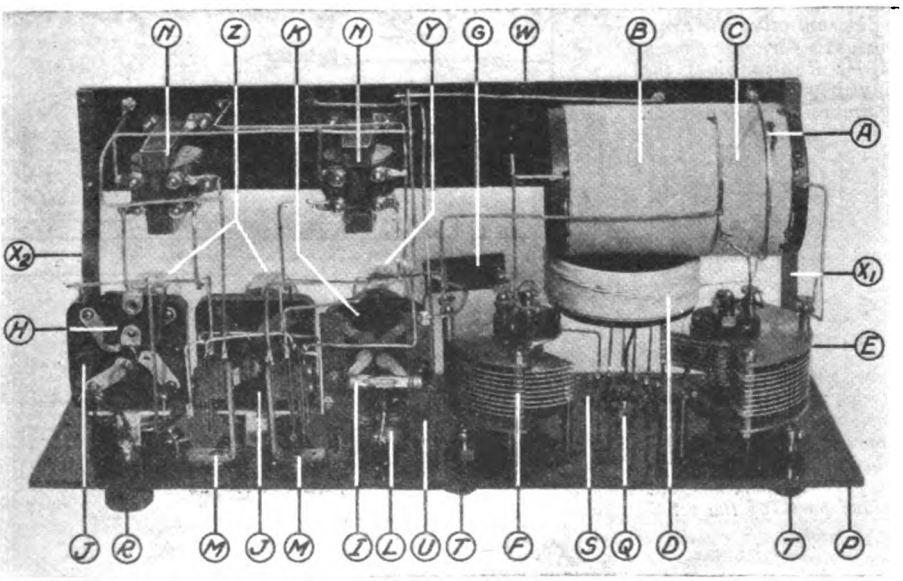


DIAGRAM OF THE FOUR-CIRCUIT TUNER

FIGURE 1: *Here are shown the exact electrical connections for the apparatus used in the new circuit; the parts are designated by the same letters that appear in the text.*



AN INSIDE VIEW OF THE RECEIVER

FIGURE 2: *This picture gives the prospective builder of the Four-Circuit Tuner a clear idea of how the instruments should be arranged in the proper positions. Notice that all of the inductances and transformers are placed well to the rear of the set, so that body capacity is eliminated while the set is being tuned. The mechanical drawings on the following pages give in greater detail the proper spacings and positions of the instruments.*

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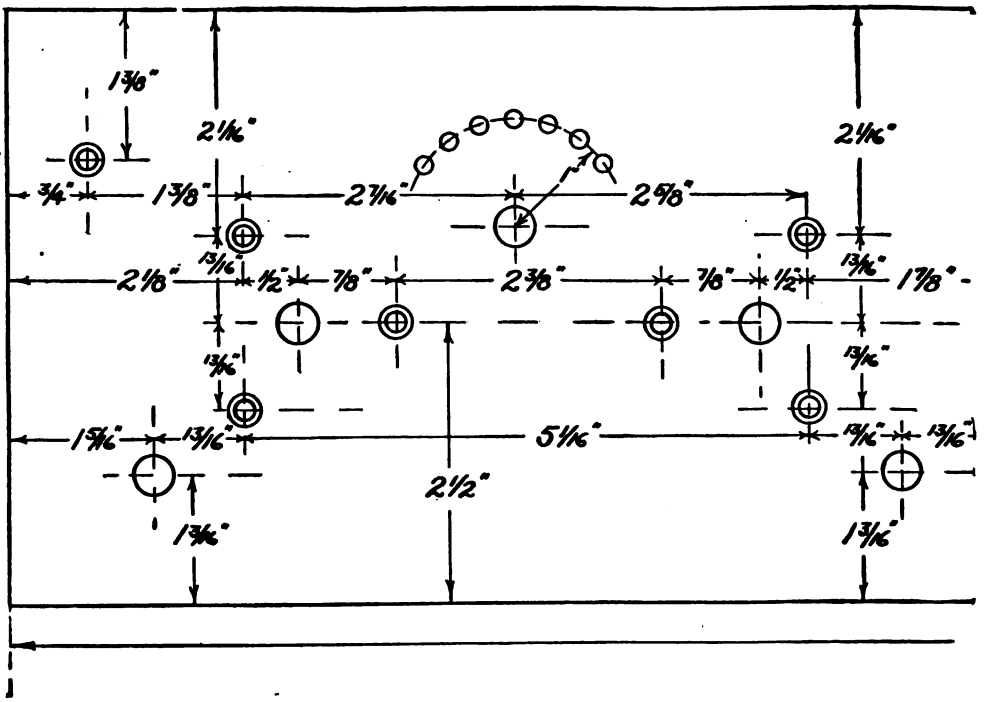


FIGURE 3
(above)
This diagram gives the exact dimensions for the main panel P; it also gives the drilling details for the holes for mounting the instruments.

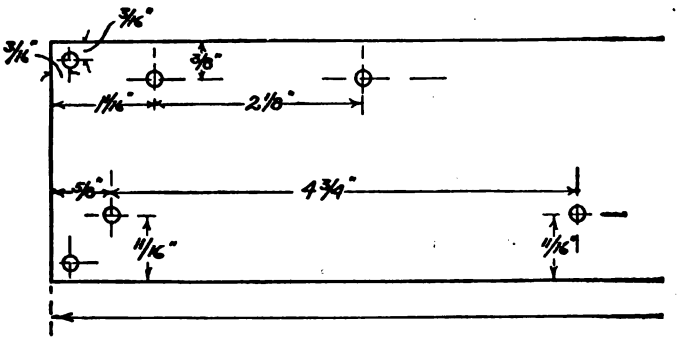
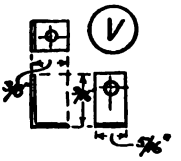
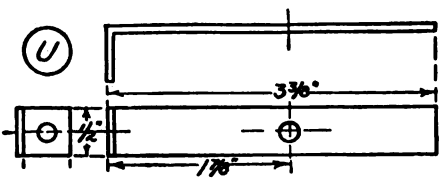


FIGURE 4
(at right)
Here are shown the exact dimensions of the shelf panel and of the brass and phosphor-bronze brackets that are used for supporting the various parts of the set.





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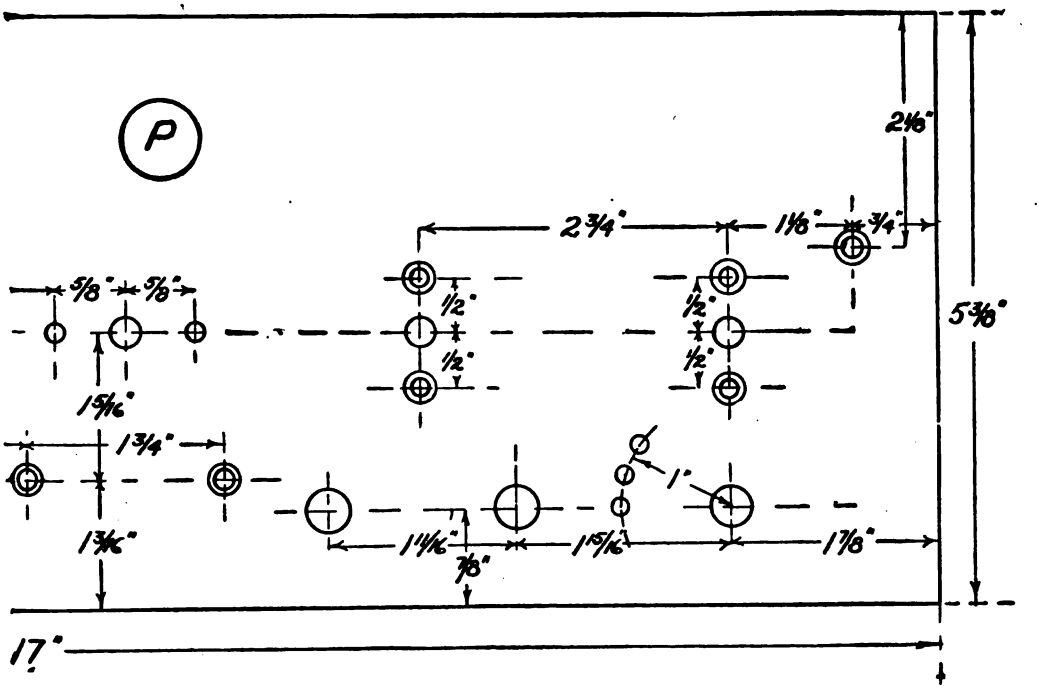

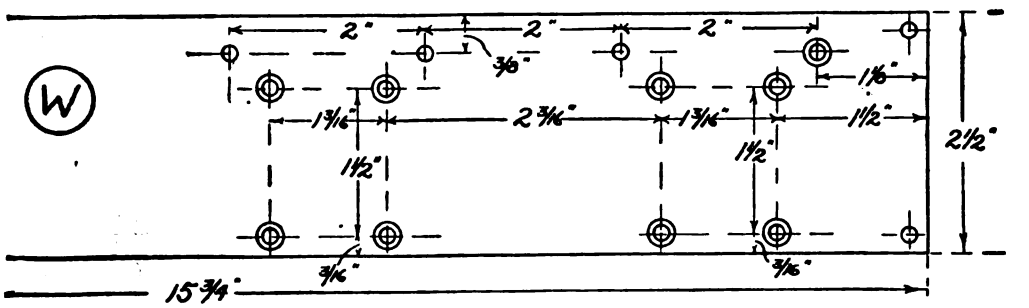

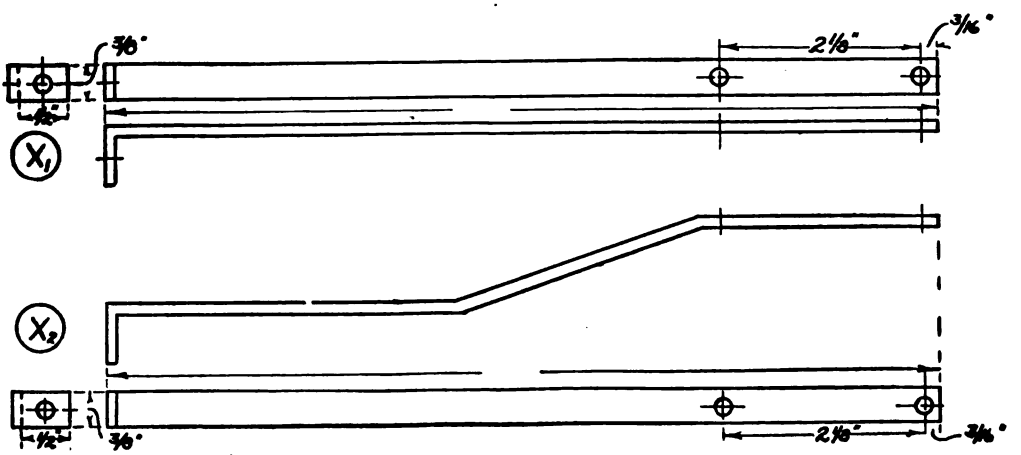

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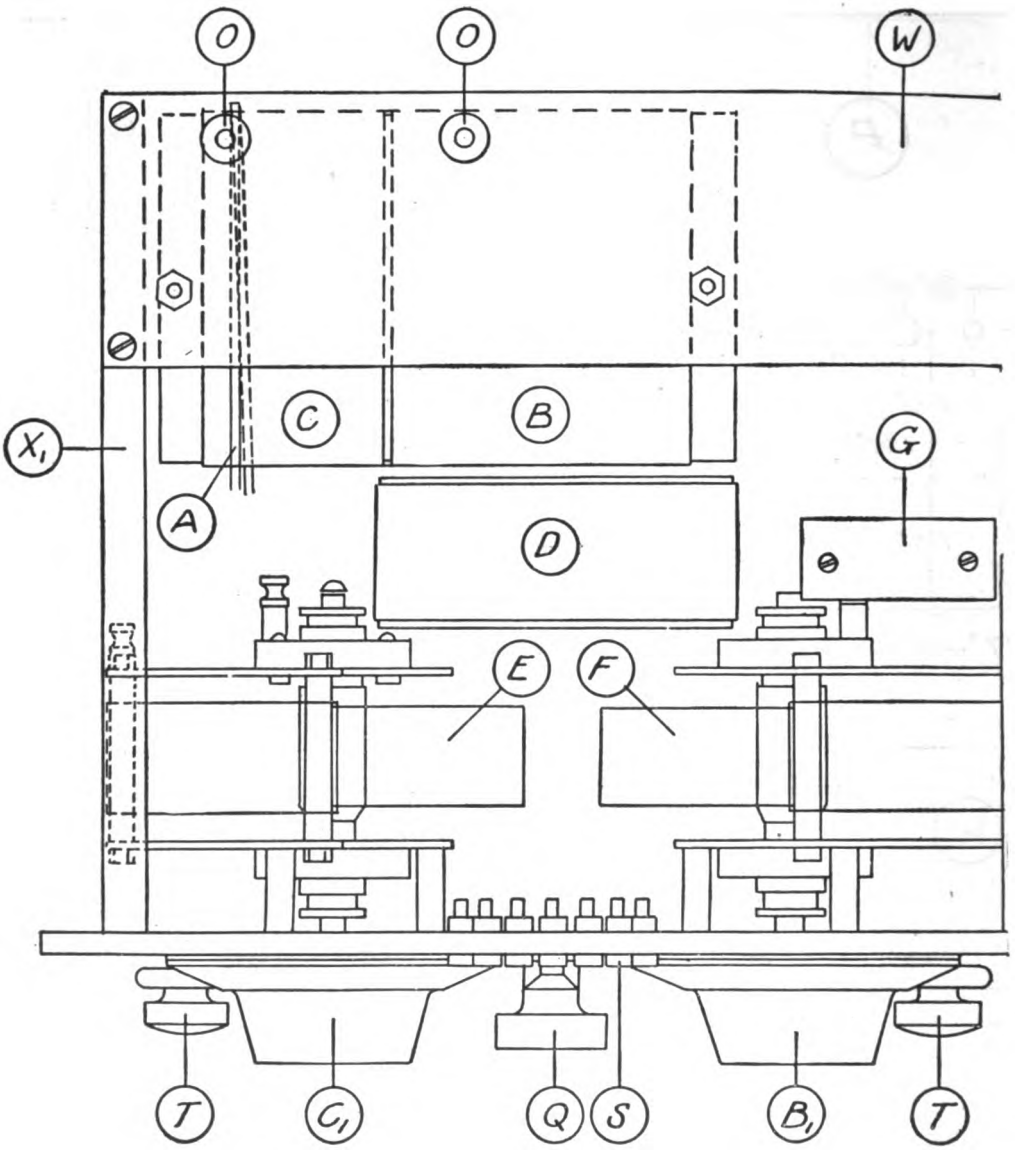

A WORKING DRAWING FOR ASSEMBLING THE SET

FIGURE 5: *A view of the set from above, showing the exact positions for the coils, condensers, transformers, tube sockets, switches, rheostats, and control dials. If the two panels used in the set are made as shown in Figures 3 and 4, the instruments will fit (as shown here) in a compact and efficient layout.*

no variometers, variocouplers, feedback coils, or tuned plate circuits are necessary. No variations of coupling are necessary, and the regeneration can be *set* and it will *stay put* over the entire wavelength range.

Another advantage of the system is that the constants of the antenna system make little or no difference on the other circuits; in other words, the set can be tuned on one antenna of totally different characteristics from another antenna and the two antennas switched with the signal still remaining tuned in. When receiving C. W. signals, the hands may be placed on the bare antenna wire without

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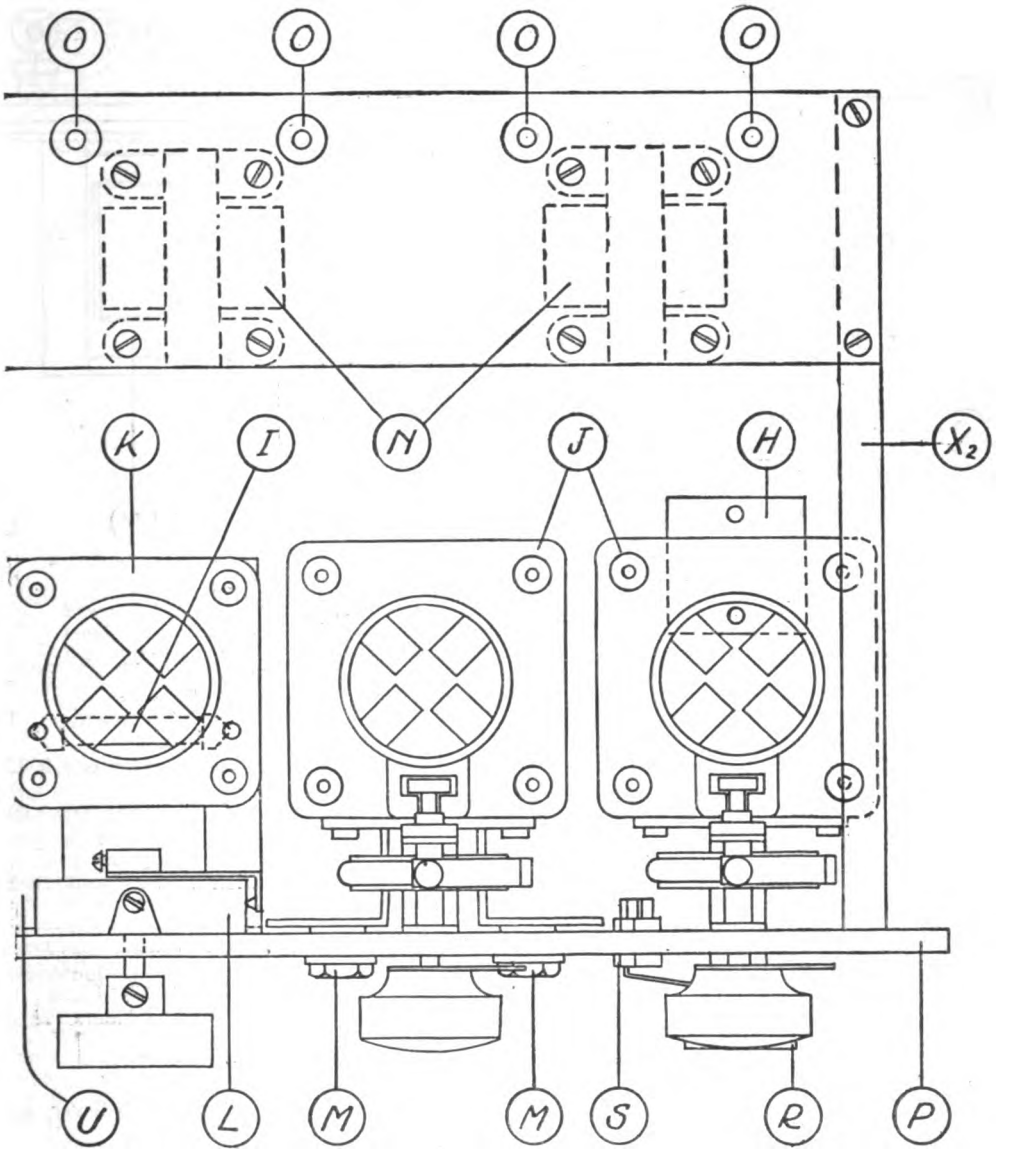

detuning the signal; in fact, the hands may be placed across the antenna and ground terminals. The antenna may be taken off or the ground lead taken away with signals still remaining tuned in but slightly weaker.

Fourth, to insure truthful reproduction we have added to the two-stage audio frequency amplifier a control for eliminating tube noises and for clearing up music and voice signals. This device makes music sound just as if it were being played in the room where it is received.

The set has, during the last few months, on all kinds and types of antennas, picked up about three quarters of all the broadcasting stations in the United States on a loudspeaker, and amateur stations in all the nine districts of this country and amateurs in other countries of this continent and in Europe.

The set as here described is not sensitive to body capacity and does not have to be externally shielded.

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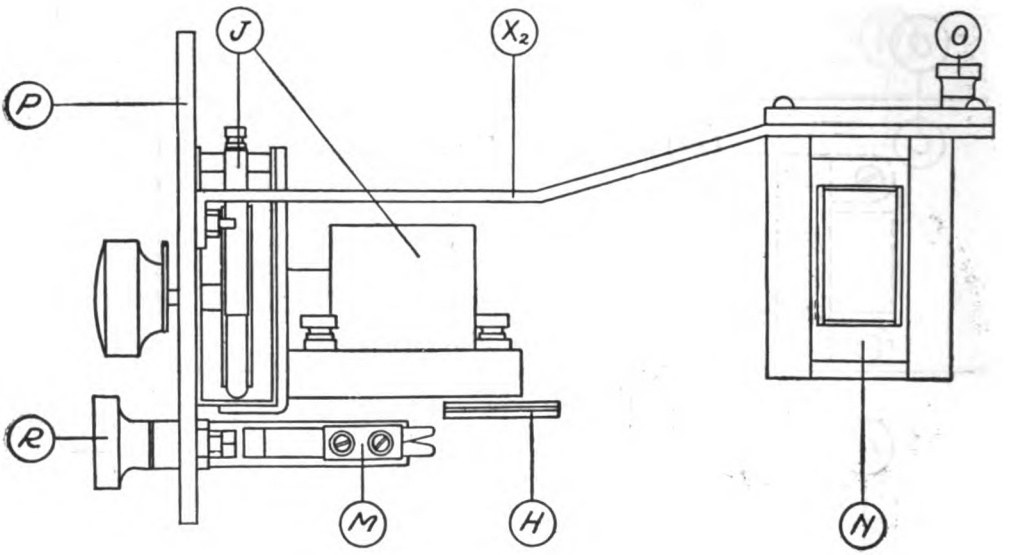

SIDE VIEW OF THE SET—FROM THE RIGHT

FIGURE 6: *This diagram shows how the rheostats, tube sockets and jacks are fastened to the main panel, and how the amplifying transformers are hung from the shelf panel in the rear. The condenser H is hung directly under the last socket and is supported by the connecting wires.*

The electrical circuit diagram is shown in Figure 1.

The Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter. In this way the prospective builder of a receiver may easily determine how to mount the instruments in the correct places and connect them properly in the electrical circuit. The same designating letters are used in the text and the list of parts below. The list of parts includes the exact instruments used in the set from which these specifications were made up; however, there are many other reliable makes of instruments which may be used in the set with excellent results. If instruments other than the ones listed are used it will necessitate only the use of different spacing of the holes drilled in the panel and shelf for mounting them.

A—primary winding, consisting of a single turn of tinned copper bus-wire, 1/16 inch square;

B—secondary winding, consisting of 65 turns of No. 18 S. C. C. copper wire;

C—reaction-stabilizer winding, consisting of 34 turns of No. 18 S.C.C. copper wire; (Coils A, B and C are wound on a composition tube, the dimensions of which are shown in Figure 8.)

D—antenna tuning-coil, consisting of 43 turns of No. 18 S.C.C. copper wire, double bank-wound, on composition tube; (See Figure 8.)

B1 and C1—Tait 3½-inch knobs and dials;

E and F—Se-Ar-De variable condensers, 17 plates, approx. .00035 mfd.;

G—Dubilier micadon fixed condenser, .00025 mfd.;

H—Dubilier micadon fixed condenser, .002 mfd.;

I—tubular grid leak, 1 or 2 megohms.;

J—Se-Ar-De combination sockets and rheostats;

K—De Forest socket;

L—Jenkins vernier rheostat;

M—Pacent or Federal jacks, one double-circuit and one single-circuit;

N—Jefferson amplifying transformers, small type;

O—Fada binding posts;

P—composition panel;

Q and R—Haydon-Fenton switch lever and knob;

S—switch points;

T—Haydon-Fenton vernier controls;

U—brackets for mounting the De Forest socket;

V—phosphor-bronze spring contacts for mounting the grid leak;

W—composition shelf panel;

X and X2—brass brackets for mounting shelf panel;

Y—detector tube, preferably a UV-201, or C-301 or a De Forest tube;

Z—amplifier tubes, preferably two C-301a's or two UV-201a's;

one cabinet, dimensions as shown in Figure 9;

connecting wire, 1/16-inch square tinned copper bus-wire;

screws and nuts to fit.

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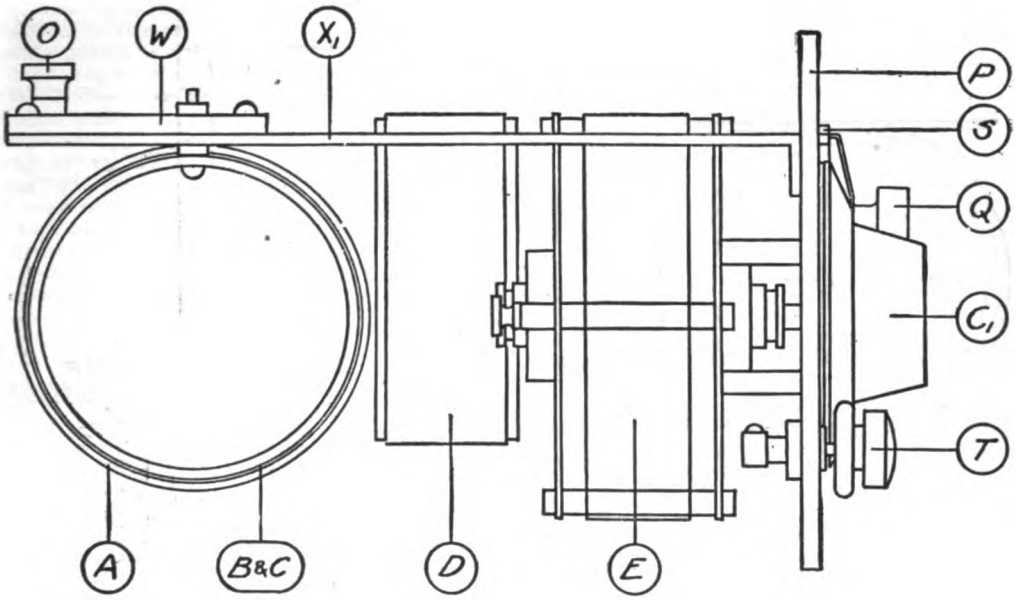

SIDE VIEW OF THE SET—FROM THE LEFT

FIGURE 7: *In this diagram is shown the method of attaching the tuning condensers to the main panel, and of attaching the coils A, B and C to the shelf panel. The antenna tuning coil D is suspended between the other coils and the condensers.*

How to Construct the Set

After procuring all the instruments for building the receiver, the amateur should set about preparing the panel P (shown in Figures 2, 3, 5, 6, and 7).

First of all, the panel should be cut to the correct size (5⅜ by 17 inches); then the edges should be squared up smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 3.

The holes outlined here with a double circle should be countersunk so that the flathead machine screws used for fastening the instruments will be flush with the panel. All the rest of the holes in this panel are straight drill holes. Sizes for the diameter of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the size of the screws and shafts of instruments that have to go through the holes.

When the panel is drilled, it may be given a dull finish by rubbing lengthwise with smooth sandpaper until the surface is smooth, then the same process should be repeated except that light machine oil should be applied during the rubbing. The panel should then be rubbed dry with a piece of cheese-cloth, and a dull, permanent finish will be the result. Or the panel may be left with its original shiny-black finish, if care is exercised so that it is not scratched during drilling.

Next, the condensers, E and F, should be fastened to the panel in their respective places, as shown in Figures 2, 5, and 7, and the dials B1 and C1 should be affixed as shown. These dials are fitted with a chuck which centers and holds fast to the shafts of the condenser without the use of set screws. This insures even running of the dials when they are revolved and eliminates wobbling.

The two combination sockets and rheostats J, should be mounted on the panel (two screws to each instrument) as shown in Figures 5 and 6.

The detector vernier rheostat L should also be mounted in its proper place by means of two screws (see Figure 5). The detector socket K will require two brass brackets U, for attachment to the panel, and these should be of the dimensions given in Figure 4. The two grid leak phosphor-bronze springs V (shown in Figure 4) are mounted on these brackets, underneath the socket. Two holes will have to be drilled in the socket, one on each side (as shown in Figures 2 and 5) for fastening with brass nuts and bolts to the brackets U. The grid leak springs are held by the same bolts.

The three rheostat knobs should now be connected to the shafts of the rheostats protruding from the front of the panel.

Place the switch points S in the proper holes drilled for them and fasten with small nuts on the rear of the panel as shown in Figures 2, 3, and 5. Insert the two switch levers Q and R and make fast in the proper manner with the nuts furnished with the apparatus.

Mount the two jacks M, the double-circuit jack at the left and the single-circuit jack at the right, as shown in Figures 2, 5, and 6.

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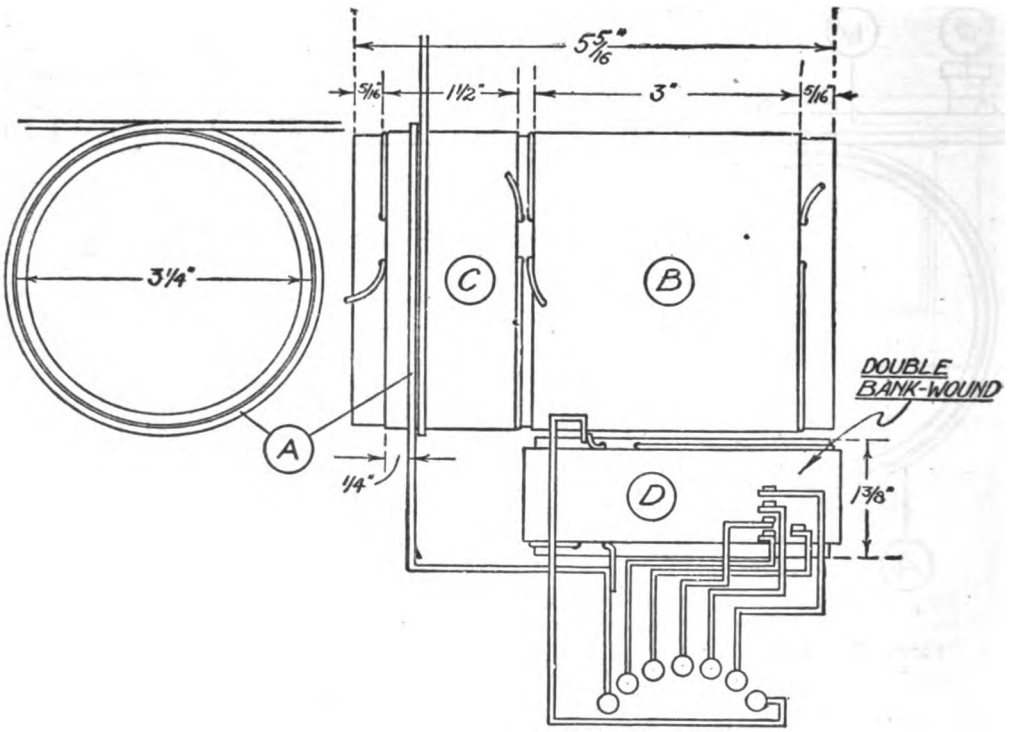

HOW TO MAKE THE COILS

FIGURE 8: *Here are shown the dimensions for the coils and the method for connecting the single turn of wire A to the coil D and to the taps S. The positions of these coils in relation to each other should be observed strictly.*

It will be noted that the two jacks should be mounted "back to back," as the space is limited. (There is really no benefit derived from using a jack in the first stage because the same results can be obtained by burning the two amplifier tubes at a low filament temperature and thus getting the same results as from one stage. This will save the tubes as they will last longer, burning dimly, than one that burns brightly.)

The last job on the main panel is to mount the two vernier controls T, for the condensers E and F (see Figures 5 and 7). These are necessary on account of the sharpness of tuning in this set.

Next, cut and drill the shelf panel W, as shown in Figure 4 and prepare the two mounting brackets X1 and X2, shown in the same diagram. These are fastened to the shelf panel and also to the main panel P, as shown in Figures 5, 6, and 7. The straight bracket is used at the left side of the set. The irregular shaped bracket X2 is used at the right side of the set, and the reason for using it is to allow space for all makes of tubes to fit into the last socket.

Now mount the two transformers N on the shelf W, using four screws to each transformer, as shown in Figures 2, 5, and 6.

The six binding posts O should be mounted in a straight line at the rear of the shelf and fastened underneath with nuts, in the regular manner.

In preparing the tuning elements great care should be exercised, for in the *exact* following of the instructions here given lies the success that can be had with the completed set.

First, cut the 3¼-inch tube to the right length, as shown in Figure 8. (If you have trouble in getting this size, use 3½-inch tubing; it will raise the wavelength only slightly.)

Start winding the coil C, finishing with 34 turns of No. 18 S.C.C. copper wire. Right next to this wind on the 65 turns of the same kind of wire for coil B. Then fasten the tube with the two coils wound on it to the shelf W with two screws and nuts (see Figure 5), and insert a washer between the shelf and the tube, as shown in Figure 7. This will leave a little space for the single turn A, which can be put on when the wiring is being done.

The antenna tuning coil, is a double-bank-wound coil on a tube the same diameter. The taps are taken off, one at the beginning of the coil, then one at the third turn, one at the 7th, 13th, 21st, 31st, and one at the end, the 43d turn.

In bank winding, the tube is shellaced with a light coat and while it is still wet, two turns are wound upon it.

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Then the next turn is run up on top of the two turns that are already completed and a whole turn is put on.

When this turn is completed the wire is turned down on the tube again and another turn completed; the next turn is run up alongside the first top turn, then down, then up, and so on. In the set described the coil D was held in place by the stiff bus wiring, but it may be fastened to the shelf by a straight piece of brass and two screws and nuts (brass).

The two condensers G and H may be attached in the proper places when the wiring is being done, as they are held in place by the wiring.

How to Wire the Set

The design of this set is such that the grid circuit wiring of each of the three tubes may be made extremely short and isolated from the other circuits. In fact, all the tuning circuits and leads are arranged so that short connections may be used. As this is the case the set may be wired with bus-bar, with little loss in efficiency.

A tinned copper square wire is recommended. It should be about 1/16 inch square. All connections should first be shaped so that they will fit, and then soldered in place.

The binding posts along the back of the shelf W (design in Figure 5) are to be connected in the following manner:

First on left, antenna;

Second from left, ground;

First on right, amplifier "B," positive;

Second from right, detector "B," positive tap;

Third from right, "B," negative, and "A," positive;

Fourth from right, "A," negative.

It will be noticed in diagram (Figure 1) that the ground and the "A," negative, are connected together.

Start wiring the filament circuit, being sure to include the rheostats in the correct side of the filaments as shown in Figure 1. *This is important.*

Wire up the antenna circuit, including the placing of the single turn A, of the bus-wire, around the inductance in position shown in Figure 8 and connect to coil D and the taps S. One end of the loop A goes to the antenna post and the other goes to the first tap S and the beginning of coil D as shown. The switch lever Q is connected to the ground post.

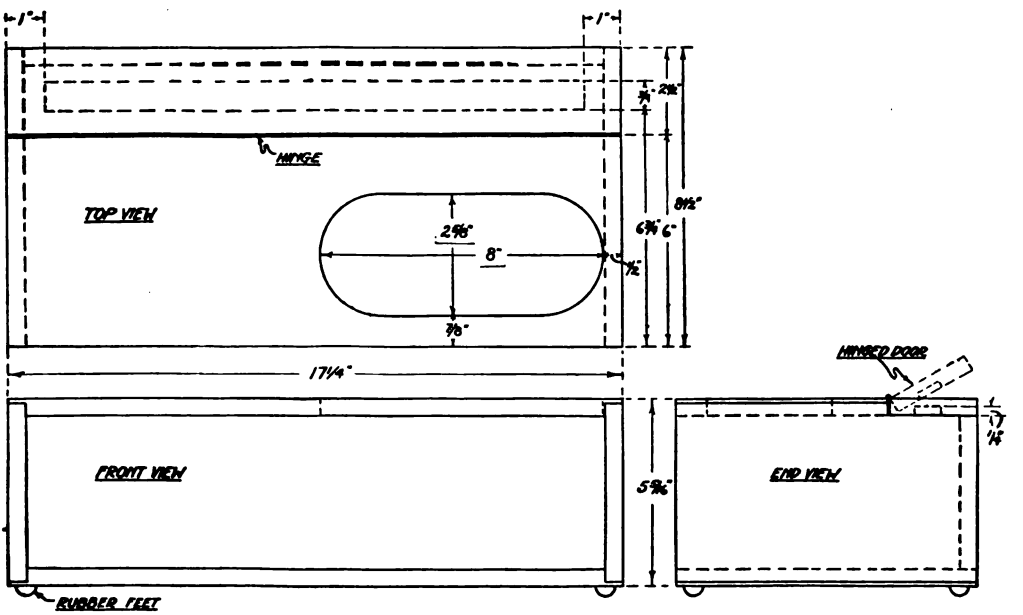
Now wire the two leads from coil C, to the terminals of the condenser E.

Then start with the secondary wiring (coil B, condenser F, condenser G, and the grid leak I) and connect exactly as shown in the diagram Figure 1.

Wire the plate circuit of the detector tube, including the jack, the primary of the first amplifying transformer and ending up at the detector "B," positive, binding post.

Next, finish up the first stage of amplification, and then continue with the second stage.

The last job to complete is to connect the condenser H to the switch lever R and the



HOW TO BUILD THE CABINET

FIGURE 9: *This working drawing of the cabinet, which contains all the necessary dimensions, may be turned over to a cabinet maker, who will be able to construct it of some hardwood—such as mahogany or oak. The hinge used is a section of piano hinge and may be finished in nickel.*

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grid of the last tube, and also connect up the two end-taps S, as shown in Figure 1. This is the tone control of the amplifier and will give the operator three separate adjustments.

After you have finished the job, sit down with some friend and check over the wiring once or twice before using the set. This will save yourself a lot of trouble in case you have made a mistake.

Operating Data

When using the set, the following hints will be of practical value:

The set may be used with any antenna that is about 100 feet long—the longer the better. It also works well with a multi-strand antenna.

By lifting up the little hinged door at the top and back of the cabinet, the connections may be made in the following order, to the antenna, ground and batteries, commencing at the left (looking at it from the front):

First post, the antenna;

Second post, the ground;

Third post, the "A" negative;

Fourth post, the "A" positive and the "B" negative;

Fifth post, the "B" positive tap for the detector, 22½ volts;

Sixth post, the "B" positive for the amplifiers.

Close the lid.

All antenna tuning is done with the switch lever Q. All secondary tuning is done with the dial B1 and the vernier control T for that dial. Regeneration is controlled by the dial C1 and the vernier T for that dial.

Place the detector tube Y in the socket, and place the telephone plug in the first jack and turn up the filament rheostat all the way. Then turn it back so that the filament is left at three-quarters brilliancy.

Now take the plug out of the first jack and put it into the second. Insert the two amplifier tubes Z, and just touch the rheostats to the first wire on the rheostat. Do not turn them up any farther. This is the way they are supposed to operate; they should not be turned up higher.

Set the dial C1 at 100, with the condenser "all in," and tune with the dial B1, until you pick up a signal. Then revolve the switch lever Q until the best tap is found. Turn up the rheostat L until the tube starts to oscillate and then turn it down slightly below this point. All further adjustments should be made with the two dials B1 and C1. The lower the value at which C1 is set the more the set will oscillate so that the regeneration can be easily controlled by the combined action of the two dials B1 and C1. You will soon get the knack.

Amateur C. W. signals should be tuned with the dial C1 somewhere between 0 and 80. All phone stations will be found to come in better with this dial somewhere between 60 and 100.

On dial B1, the amateurs tune between 0 and 15, and the broadcasting stations between 20 and 65. The antenna taps at the left will be best for amateur work, and the middle taps or the right taps for the broadcasting; it all depends on the size of the antenna, but you will soon learn the best taps to use with a little practice.

S. R. Winters

A NEW RADIO-OPERATED CODING AND DE-CODING DEVICE

This new apparatus, known as the Hebern electric code, is used like an ordinary typewriter; words are spelled out on it in any language and the machine itself does the coding. This is accomplished by means of rotating discs which are set on a key letter both at the transmitting and at the receiving end. These discs "scramble up" the message into five-letter groups and the different letters in the original message are replaced by other letters in combinations which number up to 40,303,146,321,064,147,046,400,000 distinct and different combinations. It has been estimated that it would take the whole staff of the Government's code experts at least 100 years to decode one message or even one word of one message sent out by this instrument, without the aid of the receiving machines.

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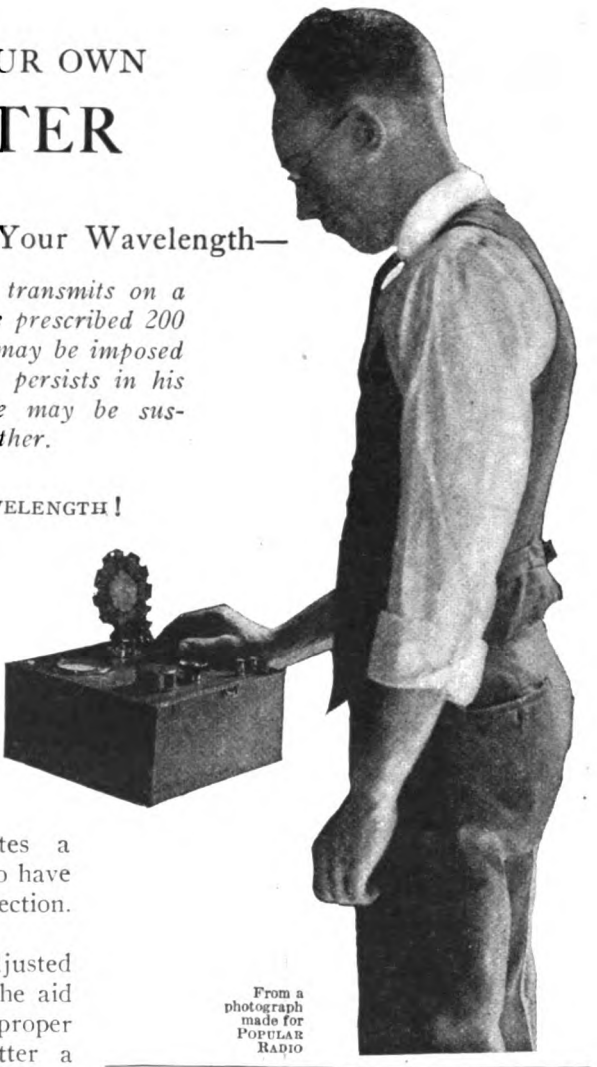
HOW TO BUILD YOUR OWN
WAVEMETER

The Penalty for Exceeding Your Wavelength—

For the amateur who transmits on a wavelength exceeding the prescribed 200 meters, a fine of $25.00 may be imposed for each offense. If he persists in his transgression, his license may be suspended or revoked altogether.

WATCH YOUR WAVELENGTH!

By W. K. THOMAS



From a photograph made for POPULAR RADIO

EVERY amateur who operates a transmitting apparatus ought to have a wavemeter—for his own protection. Yet few amateurs own one.

No transmitting set can be adjusted properly for wavelength without the aid of an accurate wavemeter. In the proper adjustment of a spark transmitter a wavemeter is indispensable, as a resonant condition between the closed and open circuits is far more essential for maximum efficiency than "antenna current."

In obtaining resonance in a tube transmitter the amateur is usually guided by the use of various voltmeters, ammeters and milliammeters. But reliance should not be placed upon guesswork in determining the length of the emitted wave. Our Government through the Department of Commerce has complete jurisdiction over radio communication and has designated the operating wavelengths of various classes of stations, and these wavelengths must be adhered to strictly in transmitting. The amateur who uses a wavelength greater than that to which he is entitled is in danger of forfeiting his license.

The amateur who wants to build his own wavemeter—and the task is not difficult—will find the following instructions of practical value. The apparatus here described is really efficient; for amateur purposes, indeed, it may well take its place alongside the justly famous Kolster decremeter.

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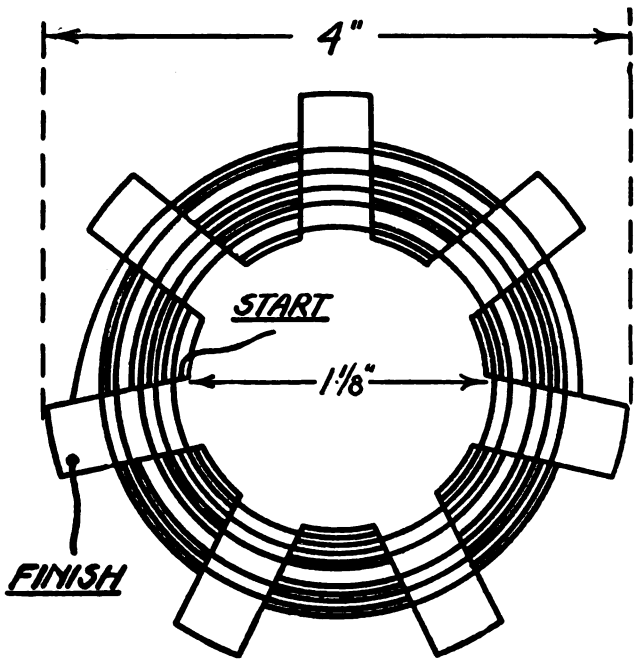

FIGURE 1

How to make the coils. Coil 1 has 20 turns on it, and coil 2 has 42 turns. This is the only difference.

The specifications call for the following material:

1 pc. bakelite 3/16 by 8½ by 8½ inches
1 Weston thermo-galvanometer No. 425
1 1½ volt flashlight cell
1 Century buzzer
1 rotary switch lever
2 contact points
1 variable condenser .001 mfd. with dial
2 binding posts
1 suitable oak or mahogany case

The schematic drawing (Figure 2) shows the electrical connections; the dotted lines represent wires which should be of No. 14 solid-copper wire covered with cambric tubing.

In Figure 6 is shown a circuit diagram, and in Figure 3 a drilling plan of the panel. Across the binding

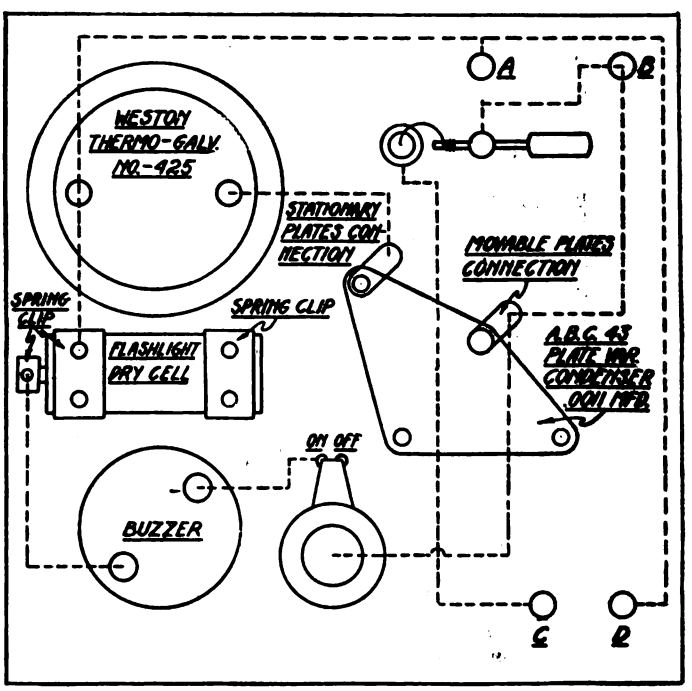

FIGURE 2

Figure 2 shows a schematic drawing of the instrument layout with the circuit connections indicated by dotted lines.

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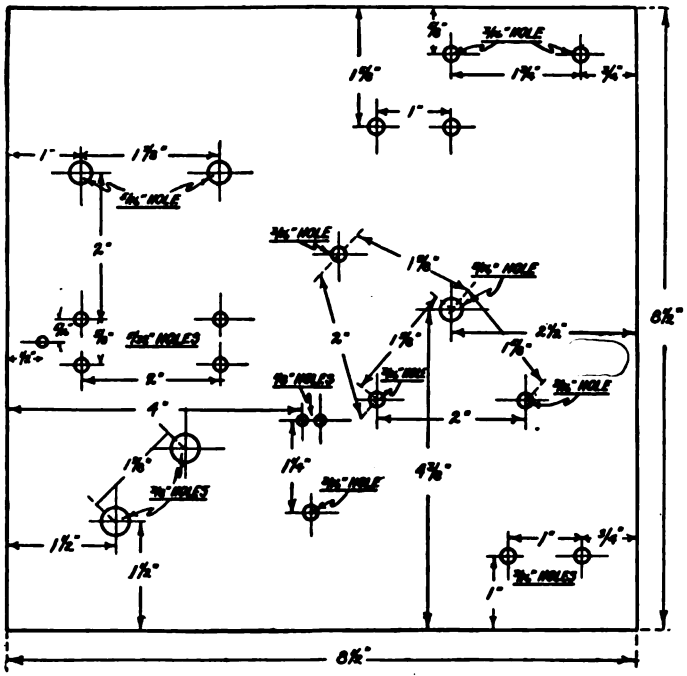

FIGURE 3

Where to drill the holes in the panel. Follow this diagram and know exactly what size the holes should be and exactly where they should be drilled.

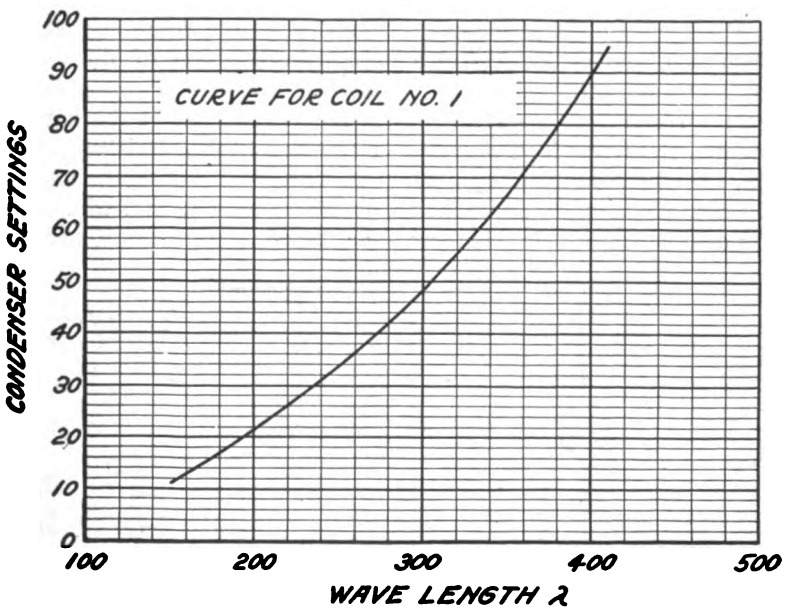

FIGURE 4

The wavelength chart for coil number 1. Run along the horizontal line, which corresponds to the number on the dial of the condenser in the wavemeter for a given setting, until you strike the curve; then run down the vertical line to the bottom of the chart to find the wavelength. Thus for a setting of 21 on the condenser we find a wavelength of 200 meters, on which amateurs transmit.

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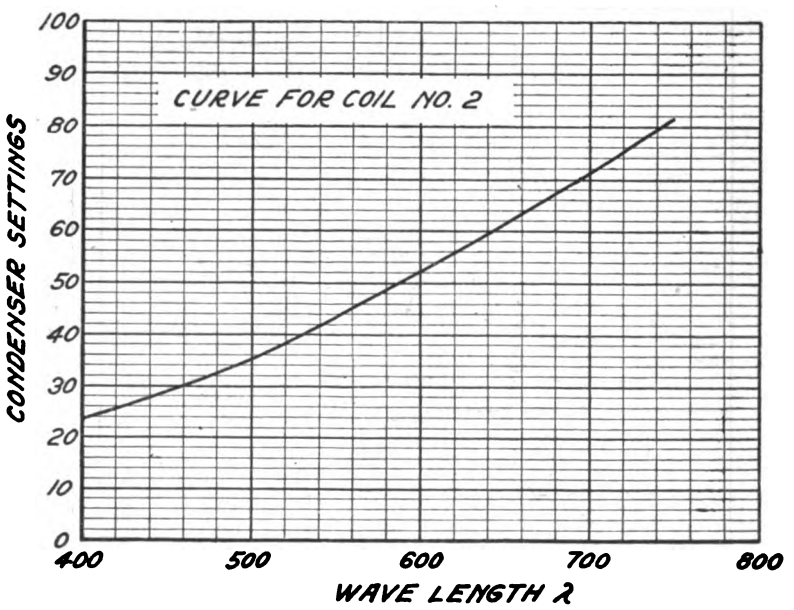

FIGURE 5

The wavelength chart for coil 2. This chart is used in the same manner as the chart shown in Figure 4. It will be noticed that coil 1 has a wavelength range of 150 to 400 meters and that coil 2 has a range of 400 to 740 meters.

posts A and B (Figures 2 and 6) are shunted the windings of the wavemeter coil which complete the circuit through either the meter or buzzer.

To calibrate a receiving set, place the wavemeter near the antenna lead-in wire, insert the desired coil across the binding posts A and B and place the rotary switch in the "on" position, closing the battery circuit through the buzzer and coil. Set the dial of the receiving set at zero and vary the position of the condenser dial on the wavemeter until the maximum sound is received in the head set that is connected to the receiving set.

Continue this process, taking readings of the wavemeter dial when the receiving dial is set at zero, 5, 10, 15, 20 and on.

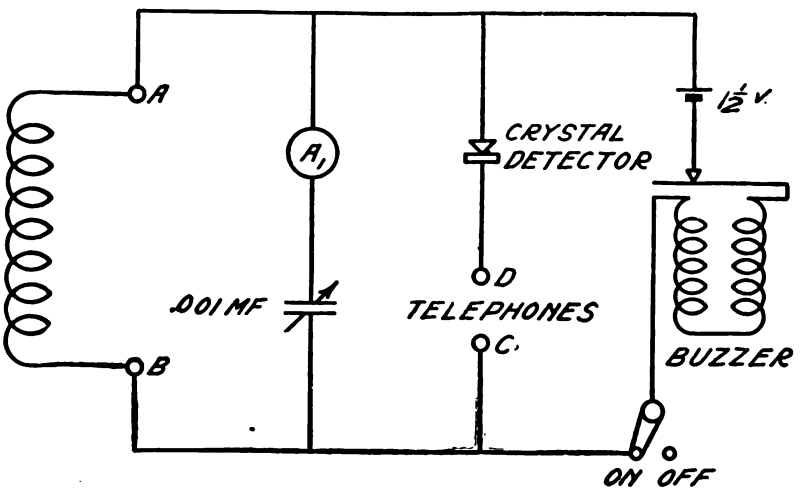

FIGURE 6

This circuit diagram shows the electrical hook-up for the apparatus. Either coil 1 or coil 2 may be used across the binding posts in accordance with the wavelength range to be covered.

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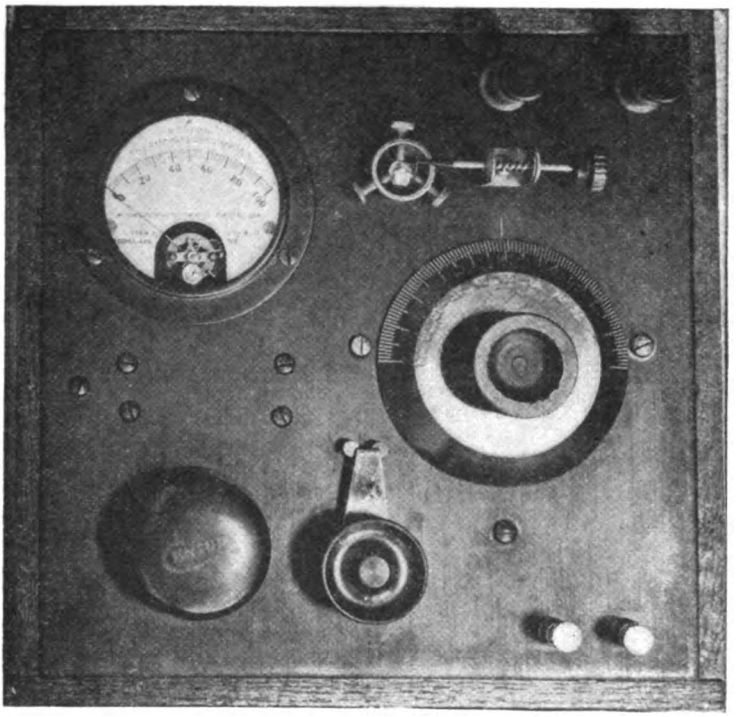

A PANEL VIEW OF THE COMPLETED WAVEMETER

With this apparatus the amateur may check up on two important points—the wavelength of the signals that he is transmitting and the wavelength of the signals that he is receiving. No radio installation is complete without this important measuring instrument.

Then by reference to the curve (shown in Figures 4 and 5) you can ascertain the exact wavelength of each of the various settings of the dial on the receiving set.

Once you have obtained the values at different points, you may plot a new curve for your particular receiver; thereafter you need merely to refer to this curve to learn at a glance the exact wavelength of an incoming signal.

This meter, it will be noticed, is also equipped with two extra binding posts to accommodate a pair of telephones to be used in conjunction with the crystal detector as shown in the circuit diagram in figure 6 and in the photograph at the top of this page.

To tune a transmitting set, the only change necessary on the wavemeter is to move the rotary switch to the "off" position; when the transmitter is in operation, bring the wavemeter near the apparatus and move the wavemeter dial until the maximum deflection of the thermo-galvanometer is noted. By reference to the curve you can immediately ascertain the exact wavelength of your transmitter.

Care should be exercised not to place the wavemeter too near the transmitter, as the thermo-galvanometer shown is very sensitive; the full scale deflection is equivalent to only 115 milliamperes. A thermo-couple milliammeter of 0-100 scale will also be suitable for this purpose.

For construction of the coils across A and B, see Figure 1. If every detail is followed closely in making the coils, the curves shown in Figures 4 and 5 are accurate within a small percentage.

The instrument described will be a guarantee that you do not exceed the wavelength allotted to you.

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Shaw Photo, Boston

WILL THERE BE BUYING AND SELLING IN THE SKY?

Sooner or later the question must be settled as to whether or not vendors of merchandise, insurance and real estate will be admitted to the realms of radio for exploiting their wares. Mr. Lee, the famous author and advertising expert, here brings up some pertinent observations on this timely topic.

Marketing Mattresses in the Ether

POPULAR RADIO does not believe that advertising matter should be intruded upon general broadcast programs, any more than it should be intruded upon motion-picture programs or the text columns of newspapers and magazines. Possibly a special waveband will some day be assigned exclusively to advertising; in which case the venture will succeed or fail in proportion as the paid publicity agents instruct or amuse us—as this article points out.

By GERALD STANLEY LEE

ADVERTISING men themselves, acting in combination with Mr. Hoover, have decided, I believe, that heaven is no place for them. They have decided that they should not be tolerated in the sky; they cannot even bear the thought of tolerating one another there!

This reveals a shrinking and a modesty on the part of advertising men that the American people have not previously been led to expect, and most of us cannot help wondering a little just now how long this shrinking of theirs is really going to be kept up.

When I first began to think of it I felt that this modesty was at least a good advertisement for advertising, that it was a good thing so long as it lasted and that it should be kept up. But on further thought I do not believe that the present feeling on the part of ad men will be kept up forever or that there is any permanent or unremovable reason why it should.

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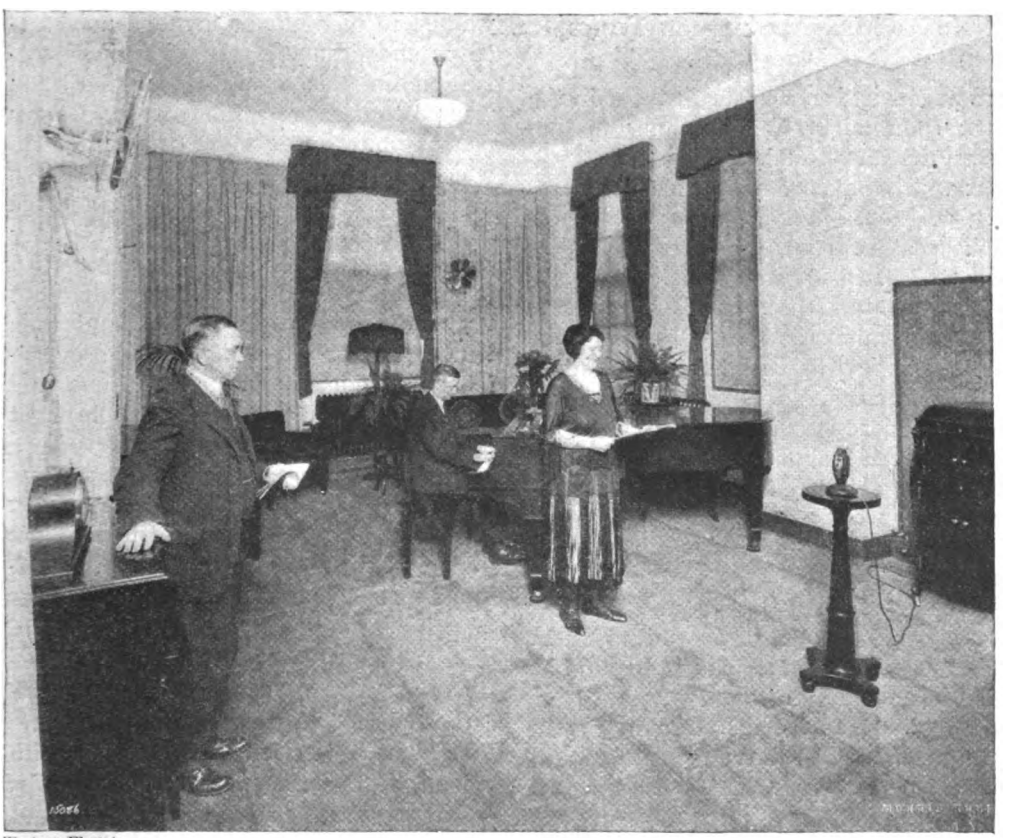
The reason given thus far for fencing off the big "vacant lot of space" above us and saying that no advertising men are to be allowed in it—the reason for saying that of course toothbrushes, mattresses, bathtubs, chewing gums and catsups and the other things must all keep out and that the air up over America must be reserved merely for breathing, soaring and other more unworldly and more spiritual interests and entertainments—is based on the idea that toothbrushes, mattresses, bathtubs, chewing gums and catsups will not behave themselves in the sky as they should.

Looking at the facts as to what advertising men would probably do with the sky if they were allowed to wander around in it nights, most people would have to admit what would happen. The air all about us from the rim of the earth up to the bottom floor of heaven would be one vast pandemonium of shouting and grabbing at people's pocketbooks.

This idea of what radio advertising would be like if let in on us suddenly is not one I quarrel with, so long as I keep looking at the facts about advertising as they are.

But when I look at the facts about advertising not as they are but as they might be, and as I believe advertising men are going to make them, I feel differently.

All that advertising men need to be is sensationally good, incomparably more



Western Electric

PRESS AGENTS MAY HIRE THIS STATION FOR 10 MINUTES FOR $100

The justly famous WEAF station in New York is for rent—at a specified price. It is maintained by the American Telephone and Telegraph Company as an experiment to determine whether or not there is a market for a toll-station of this kind.

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entertaining than the present education and the present entertainment that flourishes around up in the air; and the time will soon be at hand when people will feel that advertising men, at least some advertising men in this country, can honestly earn their right to the air—their right to butt in as a matter of course on jazz and on "The Man in the Moon."

Competition works in the air as well as anywhere else. An advertisement is not intrinsically an affront, not if it really draws; and when the Dear Public, as I have seen it do, sucks on an ad like a lollypop, even Mr. Hoover is not going to have the heart to stop it.

The time is coming when, if the best ad men do their part, the sign up across the heavens that has been tacked up now,

NO AD MEN ALLOWED ON THESE PREMISES

will have Mr. Hoover stealing out in the dark some night and reaching up between the stars to take it down.

It will be taken down at least for certain ad men. The principle will be established that if men are exceptions they will be treated as exceptions.

The minute the real Bud Fishers, Charlie Chaplins and Babe Ruths of the air once appear in the interstices of space and begin clearing their throats there, if they are more amusing, more instructive and enjoyable about a soap than other people are about the League of Nations, everybody will buzz to them to go ahead. They will be given the very floor of heaven.

People are not going to stop listening to a man who makes them want to listen, merely because he is paid a high price for being the kind of man who can make people want to listen. Making them want to listen is the thing. People will like it and they will like his being paid for it.

It has seemed to me for some time, as some of my readers know, that advertising—the art of touching men's imaginations so that they know something about themselves that they never knew before or that they never even wanted to know before—is one of the great professions. As the profession is interpreted by men who might yet be got to practice it, it calls for a kind of gift and a degree of gift which makes a man who has it and who determines men's lives with it fit to be listened to anywhere and listened to on almost any subject.

The invention of the radio telephone and the inauguration of broadcasting, instead of being made the occasion of a national snub to advertising men which they feel they must meekly bear, should be and I believe is going to be recognized and taken advantage of by many as the profession's great opportunity.

If the advertising men of America had wanted to pick out or arrange a picturesque and dramatic crisis for their profession in this country, if they had wanted to arrange a kind of gunpowder plot of publicity—a blaze of limelight in which to prove that advertising must be recognized as one of the greatest and the most honorable of the professions—they could not have done a better thing than to get themselves sensationally shut out of heaven, as they now are, and then with everybody looking on and everybody listening, begin doing things and saying things that will make people want them invited back again.

Perhaps the best way to make a start would be for The National Association of Advertising men to plan out and get under way what might be called a national tournament of advertising, a series of prize tests, and proceed to present to the American people in the quickest possible time advertisements that the American people would want broadcast.

A great profession is confronted with a loud, plain challenge from the people. It has a chance to look itself over and sort itself out. People are already interested in our national advertising men. They would be especially interested in seeing which are the ones that can get

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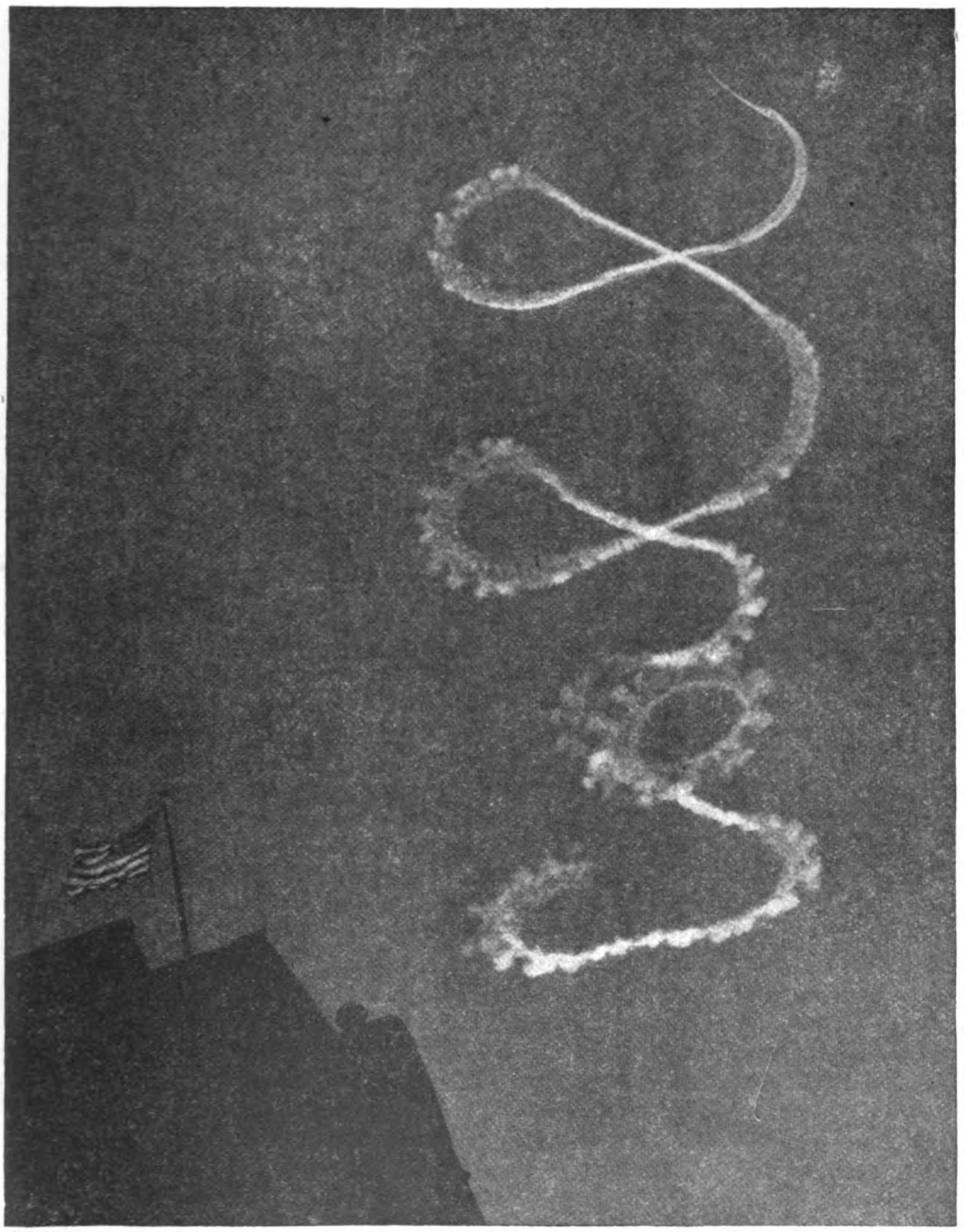

© Jack Sussman

THE "WRITING" ON THE FLOOR OF HEAVEN

The use of radio for controlling the airplanes that have indulged in the spectacular sky-writing of advertising slogans in London and New York has become more than mere theory; recent experiments in England indicate that planes guided by living pilots may soon be replaced by planes controlled by radio from ground stations. The "writing" is done by means of smoke from special devices that eject 250,000 cubic feet a second; the letters are about a mile high. The above photograph was made while Captain Cyril Turner was sky-writing the telephone number "Call Van 7100," about 10,000 feet above New York.

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invited into the sky and which will be kept out.

Instead of saying sweetly and modestly, with a whole nation looking on, that they agree that the men who belong to the advertising profession cannot compete with other human interests and activities in earning the right to be allowed in our new annex on the world, our best advertising men, I believe, are going to accept the challenge.

The main principle which should be employed in determining the question of advertising in the air is the great democratic and spiritual principle that people should never be treated as if they were alike.

The idea that all men are created free and equal is not an idea anybody really believes as it is usually interpreted. It is a mere Fourth of July incantation. Nobody who accomplishes anything or lets anything be accomplished through him ever acts as if it were so. Every man in America gets up every morning and goes to bed every night proposing to be treated as if he were somebody in particular. Advertising men, like the rest of us, expect to suffer the penalties of being individuals.

The very essence of democracy, the juice and gusto of the whole idea, lies in the fact that we in this country do not believe that society is put up in big, soggy, undigested lumps of people. We dissolve these lumps into real human beings and treat them as they really are. The idea that all the men in any group or in any profession should be lumped together and treated in the same way by the government and by the laws of the people may be convenient, but it is superficial and lazy and in the long run expensive and drains the creative resources and finer powers of a nation like ours.

The only thorough, honest, economic, ethical manner of dealing with crowds or masses of men is never to give them privileges as if they were all alike. They are not all alike and they all feel and know that they are not alike; in their hearts they don't want to be alike and they hate to be treated as if they were. It is an anæmic, overworked and tired thing for our government to deal with advertising men as a group. If the government does not want to devote its brains to picking out some advertising men who are good enough for broadcasting, the National Advertising Association can establish publicity tournaments or adopt other means to determine exceptional men and to have them dealt with as a great nation wants them to be.

One of the biggest shoves forward that our civilization, our buying and selling civilization, is going to have, will come when our inventors perfect talking back in the sky. The first minute people can clap and boo in the sky, can make a man blush or stutter when he gets up to talk in it, millions of us who have been waiting to get even with some ad men in this country—ad men who have been hitching at our elbows and hollering in our ears half our lives—millions of us are going to have a heavenly time.

Incidentally, the advertising profession is going to get its reckonings and take its soundings. It is going to front itself and confront the people with facts that nobody can explain away. We shall spell out the names in the sky of the men whose advertisements grip. Publicity in America at last, instead of being a kind of splendid national guesswork, will proceed to establish itself as both a science and an art.

In the meantime, until our inventors perfect some suitable inexpensive device for sky back-talk or at least for taking a rising vote in the air, the best arrangement for determining which of our ad men should be let in to the sky would seem to be a vote by mail. We shall have to fall back on some such preliminary test placed before the public, as the National Advertising Association or some like organization may, for the glory of the profession, devise and set up.

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HELP *your neighbor. If you have discovered any little Kink that helps to eliminate trouble in your radio apparatus, or if while experimenting with the connections of your set you should run across some interesting phenomenon, or if you should discover some new hook-up that gives better results—send it to the "Listening In" page.*

The Senate Fails 3,000,000 Radio Fans

THE failure of the Senate to pass the White radio bill was a grave disappointment to the great army of radio fans as well as to the radio industry. To meet the emergency which has thus been created, the Secretary of Commerce, Herbert Hoover, re-convened the Radio Telephony Conference Committee of last year, with the purpose of working out a practical plan of action to tide over the period until Congress assembles again. What this Committee did—(it is in session as this number of POPULAR RADIO goes to press)—will be told in the June issue of this magazine by Mr. Paul Godley.

* * *

A New and Improved Vacuum Tube

AMATEURS who have advanced beyond the crystal-detector stage of development will be interested to know of the recent arrival of a brother of the UV-201 tube, popularly known as the "radiotron." Here is a brief description of it:

A new and improved radiotron, type UV-201-A, superior in many respects to the UV-201 tube and designed to supersede the latter, has recently been announced. While in outward appearance the new tube resembles its predecessor (with the exception of a slight discoloring of the bulb) the new tube incorporates several distinctive features. For instance, it contains a new and improved filament that requires only one-quarter of an ampere (.25) at five volts across the terminals of the filament; with this current the filament emission averages about five times that of the UV-201 tube. The filament, however, when burning at normal brilliancy, has a temperature materially less than that of the UV-201 tube.

The tube has an exceedingly high vacuum, is quiet in operation and produces no inherent tube noises. The high vacuum assures uniform characteristics. It is particularly adapted to radio frequency amplification.

In its operation as a detector, radio frequency or audio frequency amplifier, the results obtained are exceptionally independent of filament adjustment. Critical adjustments of grid leak or grid condenser are not required.

The new tube may be used in any equipment which at present uses the ordinary tube and will give improved results. No adaptor is necessary when the standard four-prong socket is used.

If the filament is supplied by a 6-volt battery, the resistance of the filament rheostat should be at least 4 ohms, preferably 6 ohms.

* * *

Theatrical "Try-Outs" by Wholesale

HERE is a novel application of radio to the work of the singers and instrumentalists of the stage:

The musician and actor sell their goods largely by sample. Before the theatre manager engages singers or instrumentalists, he wants to see or hear them. For which reason a great deal of the performer's time between engagements is spent in appearing before managers for private tests. This is particularly true in the new field of musical opportunity opened up in moving picture theatres, for where there are only a few

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cities in the United States far enough advanced musically to support grand opera, even for a short season each winter, even small towns now have their picture palaces and good operatic music is heard in them fifty-two weeks a year.

In Baltimore recently, a couple of young singers who have been successful in putting on "twenty-minute operas" in moving picture theatres, made a successful trial of radio as their booking agent. Justin Lawrie, tenor, and Fernando Guarneri, baritone, make their own condensed arrangements of famous operas. Moving picture opera is pretty strenuous work, involving four or five performances a day, including Sundays and holidays, and often the doubling up in more than one part of the program. Taking one's samples around in between times and singing for managers with a view to booking future time, is just so much more work.

Lawrie and Guarneri find that it can be done better by radio. Scheduled to "appear" recently on a Baltimore broadcasting program, they wrote moving picture musical directors and theatre managers within a radius of several hundred miles around Baltimore, enclosed programs from the theatre where they were then giving twenty-minute operas, and asked that their radio performance be listened to as a sample of their work. Several engagements were secured in this way, and they expect to use radio regularly in future bookings. For the singer, instrumentalist, quartet, chorus and orchestra, radio seems to be an improvement in booking because it enables the performer to show his samples to more than one prospective purchaser at the same time. It is estimated that there are now at least three thousand moving picture theatres throughout the country in which such artists seek and find engagements. If they use radio to secure booking in paid engagements, it may help to solve the problem, "Who is to pay the radio performer?"

JAMES H. COLLINS

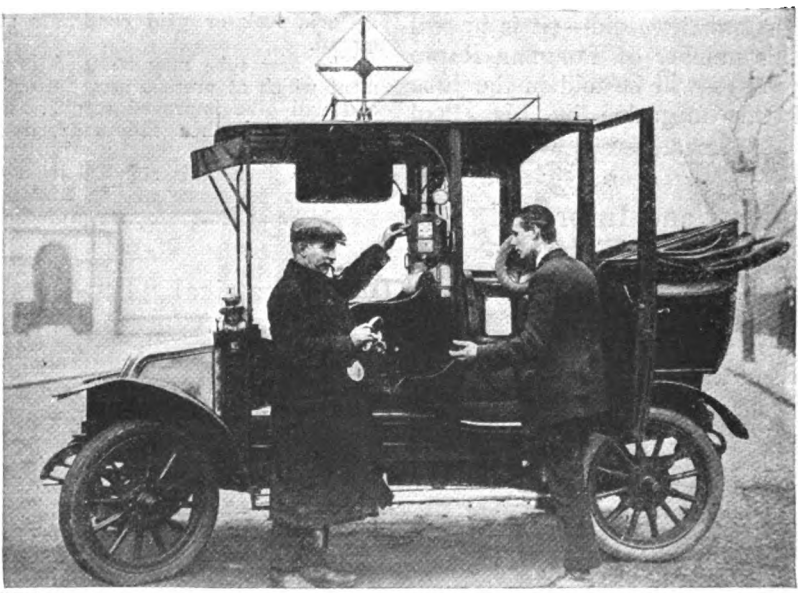
* * *

A Testing Battery for 11 Cents

IF you own—or can borrow—a silver dime, and can find a drop of ordinary vinegar about the kitchen, you can create a miniature electric battery that is quite good enough for testing your headphones. This tells how to do it:

Take a dime and a one-cent piece and place them 1/16 of an inch apart. Then place a drop of common vinegar between the coins, and take care that the vinegar touches *both* coins. Nitric or sulphuric acid can also be used to a good advantage. Lastly, take the phone terminals and move them on the coins, for a contact must be made on both terminals. If you hear a faint scratching sound in the receivers you will know that your phones are working.

WALTER A. WACHHOLTZ



Keystone

RADIO ENTERTAINMENT—WHILE THE METER CLICKS

An ingenious London taxi-driver not only lures his trade by means of a receiving set installed in his car, but often collects additional fares while his patrons remain seated until the conclusion of an interesting program.

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South Sea Love Songs in New England

TO listen in upon the actual folk-music of the world, played and sung by native musicians in their native lands, is one of the startling possibilities suggested by the rapid development of radio apparatus. Indeed, this possibility is already being realized, as Mr. Dunlap points out:

Radio followers who have had the pleasure of listening in to the melodies of New England from station WBZ in Springfield, Mass., Southern medleys from WSB in Atlanta, Ga., and Western songs from WOC in Davenport, Iowa, may increase their concert range by tuning in to the 400-meter wavelength of PWX in Havana, Cuba, which is now broadcasting in the evening, Cuban songs and tropical dance music. Experimental tests have been heard as far north as New Jersey; as the grade of radio reception is improving, it is expected that the radio waves of Cuba will be heard throughout the entire United States.

The installation of a broadcasting station on the island of Cuba indicates that the music of radio is gradually going to travel from continent to continent, first by advancing from island to island, as did the ships of Columbus. Radiophone broadcasting of concerts and other forms of entertainment is still in its elementary stage. Just as the baby learns to walk by stepping from one chair to another, so the music of radio will advance around the world from island to island before gaining sufficient strength to leap from continent to continent.

Many broadcasting stations have a power of 500 watts. Engineers predict that powerful water-cooled vacuum tubes now being developed will be capable of hurling 100,000 watts into space. Already the 500 watts of station WOR at Newark have carried the human voice across 3,000 miles of ocean to London, where listeners-in caught the voice and reported it by cable.

The performance of radio stations in transoceanic code reception at the present time casts a light on the future possibilities of radio telephony. An operator in the United States listening to Nauen, Germany, can, by slightly turning a dial, tune out the German messages and hear Bordeaux, France, or Honolulu. Radiophone listeners will soon find that by a simple tuning adjustment, they will be able to skip around the earth in the twinkle of an eye to enjoy the melodies of each country, rendered by the natives themselves.

The radio concerts in the future will not be confined to the United States but every country in the world will represent the stage. Russian artists will be able to sing or play in Moscow and have their music heard just as clearly in New York as in the radio studio in Russia. One will be able to listen to the strains of American music played in Washington by a United States Navy band, or tune to the wavelength assigned to the British Isles and pick up the English folk songs broadcast from London, or French airs played in Paris. In a like manner will the songs of Spain and sunny Italy, the melodies of Norway, Hawaii and Japan be ever present on different wavelengths in the ether lanes.

ORRIN E. DUNLAP, JR.

© Keystone View Co.

A LITTLE "LIGHT" ENTERTAINMENT

By merely throwing her antenna wire over a metal street lamp and attaching the ground wire to a man-hole cover, this young London radio fan is demonstrating how obsolete has become the phrase "deaf as a post." This particular lamp-post is serving as an aerial for receiving programs from the Eiffel Tower in Paris.

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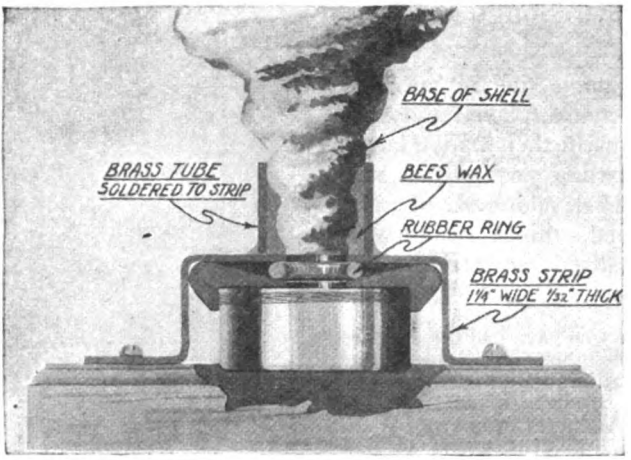

HOW THE LOUDSPEAKER MADE FROM A SEA-SHELL IS ATTACHED TO THE EAR-PIECE

The telephone is set into the shallow hole in the wooden base, and the small rubber gasket is laid in position. The sea-shell, which has been previously secured to the brass tube and strip as described, is then placed in position and secured to the base by means of two wood-screws.

A Skeleton as a Loudspeaker

FROM England comes a practical idea for using a sea-shell as a part of the amateur's home-made set. Not only does this boney object of nature give excellent results but it combines low cost with real beauty:

The chief part of a loudspeaker is the telephone—for, whatever its name might imply, the ordinary loudspeaker is only a single receiver ear-piece with a horn of some sort mounted on it. It requires at least two tubes to obtain a reasonable volume of sound unless the amateur enjoys the questionable good fortune of being in close proximity to a transmitting station. A single high-resistance receiver would be suitable. The receiver shown in the photograph is a 3,000-ohm telephone.

The base is made of mahogany and a shallow hole turned in the middle to keep the body of the receiver in place. The horn, as will be seen from the photograph, is a large sea-shell. A piece of 1/32-inch brass strip, 1¼ inches wide, is bent to the shape given in the sketch. It just clears the ear-piece, and a soft rubber ring is clamped round the centre hole. A piece of 1¼-inch outside diameter brass tubing is soldered on top of the strip.

The horn was cemented in place with beeswax. It was propped up in the right position and the hole at the bottom stopped up to prevent the wax entering. It was warmed up and molten wax poured round it and left to cool. This done, the result was a working instrument that was as handsome and practical as it was easy to make.

A tin or zinc horn would also serve. This could be made conical with the top slanting downward at about 50 degrees, and could be soldered straight onto the brass bridge-piece. No dimensions have been given in the drawing, as these will depend upon the size of the telephone receiver used. A good size of horn would be about 10 inches high and 4 inches in diameter.

NORMAN EDWARDS

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How the Weather Does and Does Not Affect Radio

NEITHER wind nor rain have a bad effect upon radio transmission or reception; indeed, stormy weather is usually "good weather" from the point of view of the radio fan. Several common misconceptions on this subject are cleared up in the following contribution from an English correspondent:

What we commonly call good weather is not necessarily good weather for radio, and what we commonly call bad weather is not necessarily bad weather for radio. A dark, rainy day, for instance, is often an extremely good day for radio; indeed, it is during the stormy days of winter that most radio records are broken. The reason is that radio waves are entirely independent of air waves and of merely atmospheric disturbances.

Neither wind nor rain need have a bad effect on radio. The collection of moisture upon the insulators may cause a leakage of radio energy to the ground, but this is purely a mechanical fault that can be eliminated by the use of corrugated insulators. Radio waves do not constitute an electric current which flows down to the ground on the first convenient conductor. If a wind is so strong as to shake the antenna it may cause difficulty in tuning, but that is the only trouble a wind will give. The speed of the highest wind (one to two miles a minute) is so trifling compared to the speed of radio waves (186,000 miles a second) that even if an air wind could affect radio waves, the effect would not be appreciable.

There are three reasons why the conditions are not quite as favorable to radio work in summer as in winter:

First, the increased foliage of the trees brings about an increased absorption of radio energy, and this permits less of it to reach the actual antennas. Each tree acts virtually as an antenna, and the district becomes too "crowded" for good radio work.

Second, the brighter solar light in summer ionizes the atmosphere and causes a "dampening" of radio energy.

Third, there is more interference due to static in summer than in winter.

But even so, radio work can be carried on with success in summer. It is foolish to conclude that weather conditions at any time of the year can seriously interfere with radio. Last winter steamers off the coast of Colombia picked up American broadcasting from stations sometimes as far as 2,000 miles away! And the weather conditions in the tropics are infinitely more unfavorable all the year round than they are in the United States in summer!

Don't be discouraged about "summer radio." Take a set along with you on your vacation.

JOHN BULMER

A "HOME-MADE" OUTDOOR ANTENNA

By driving a nail into its top and bottom and making connections in the way that is shown above, any tree may be converted into an antenna that will actually work. And this antenna is the one kind that will be more efficient in summer than in winter, for the very foliage that is regarded as an "unfavorable" radio condition will make it absorb more energy.

* * *

How to Make a Spider-Web Coil from a Phonograph Record

HERE is a time- and money-saving hint from a practical-minded reader who made the spider-web coil that was described in detail in the October issue of POPULAR RADIO:

In the construction of this coil I discarded the composition sheet specified and I took an ordinary ten-cent phonograph record instead. I let this soak in hot water; then I made the cuttings that were required. (When the record is soft, this cutting can be made without cracking the record.) I then used it as the form on which to wind the coil. A phonograph record, as a form, has these three advantages: it insulates well; it is cheap and it is easily handled. A coil wound on it has a neat and workmanlike appearance.

WALTER H. SANDT

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THIS *department is conducted for the benefit of our readers who want expert help in unravelling the innumerable kinks that puzzle the amateur who installs and operates his own radio apparatus. If the mechanism of your equipment bothers you—if you believe that you are not getting the best results from it—ask* THE TECHNICAL EDITOR.

THE flood of inquiries that has poured in upon the Technical Editor has not only furnished evidence of the need of this department: it has also necessitated a system of handling the correspondence that will insure the selection of and answer to only those questions that are of the widest application and that are, consequently, of the greatest value to the greatest number of our readers. Our correspondents are, accordingly, asked to cooperate with us by observing the following requests:

1. Confine each letter of inquiry to one specific subject.
2. Enclose a stamped and self-addressed envelope with your inquiry.
3. Do *not* ask how far your radio set should receive. To answer this inquiry properly involves a far more intimate knowledge of conditions than it is possible to incorporate in your letter.

¶ *In justice to our regular subscribers, the Technical Editor is compelled to restrict this special service to those whose names appear on our subscription list. A nominal fee of 50 cents is charged to non-subscribers to cover the costs of this service, and this sum must be enclosed with the letter of inquiry.*

QUESTION: Would a variable condenser help me any if it were used instead of the ordinary fixed condenser in the grid circuit of the vacuum tube detector? My set seems to be hard to keep from oscillating and although I can hear distant stations, reception is accompanied with a loud whistling sound.

E. JAMES EDSON

ANSWER: The variable condenser will enable you to tune out this whistling, due to oscillation, but it will add one more control to the set. However, as this will be necessary only in the case of tuning in the far-distant stations, you may leave this condenser set at a fixed value most of the time.

* * *

QUESTION: I am a beginner and would like to know a good hook-up for a crystal detector and a loose coupler.

J. B. EMERSON

ANSWER: You will find the circuit you require in Figure 5, page 212 of the November issue of POPULAR RADIO.

* * *

QUESTION: The diagram Figure 4, page 60, of the January issue of POPULAR RADIO, illustrates a circuit that shows three stages of radio frequency amplification, detector and two stages of audio frequency amplification. The coupling arrangement between the radio frequency amplifiers and the detector is a three-coil honeycomb mounting with suitable coils. I want to use this circuit, but I would like to eliminate the tickler coil L3, and use a variocoupler for the coils L1 and L2.

S. B. CROZIER

ANSWER: This modification should work well. If you have a variocoupler which has a tapped primary winding, you may also eliminate the condenser C3 and improve tuning.

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QUESTION: Please give me the hook-up and particulars of the Flewelling super-regenerative circuit. I would like to know if it will work on an antenna and on a loop.

R. B. FOSTER

ANSWER: In the diagram (Figure I) you will find the circuit. The parts for the set are the following:

L1—honeycomb coil, L-50
L2—honeycomb coil, L-75 (a variocoupler may be used instead of coils L1 and L2.)
VC—variable condenser, .0005 mfd.
GC—grid condenser, .00025 mfd.
GL—grid leak, variable, 1 to 2 megohms
C1, C2, C3—mica fixed condensers, .006 mfd.
R1—low resistance, variable .25 to .75 megohms
R—filament rheostat 5 ohms
Tel.—telephones or loudspeaker
"A" and "B" batteries to suit tubes used.

Any type of hard tube may be used, including the 1½-volt filament tubes. All tuning is done in the same manner as is usual with the ordinary regenerative set. The variable grid leak GL plays a large part in tuning in and clearing up the signals. It will be best to experiment with the "B" battery voltage until the best voltage to use is found. This will vary between 22½ to 100 volts for the loudest results.

The set may be used with an antenna and ground if they are connected across the two wires marked XX on the diagram. The set may be used with either the antenna or the ground alone if it is connected to the upper wire X. If a loop is used it should be connected across XX. The set will function satisfactorily, however, up to distances of 50 miles without any antenna or ground of any kind.

A high pitched whistle will be heard in the telephones during reception, but this can be regulated and considerably reduced by adjusting the grid leak GL.

* * *

QUESTION: Does wind affect radio waves? I have noticed that during a heavy windstorm it is difficult to tune in, and keep tuned in, signals from broadcasting stations, especially the more distant ones. I have a single circuit regenerative receiver with two audio amplifier tubes attached to it.

F. R. SMYTHE

ANSWER: Wind does not affect the radio waves. They travel at the speed of light (186,000 miles a second) and the mile and a half a second of even a 90-mile hurricane would not have much effect against this great speed. Besides, the wind is a wind of *air*, and the radio waves pass through *space* and not through the air as a medium, so that there is no conflict between the two. What you are experiencing is a detuning of your single circuit receiver by the changes in capacity as your antenna swings in the wind. As it swings, the relative capacity varies, for the capacity of the antenna is inversely proportional to the distance between the antenna and the ground. In the type of receiving set that you are using, the antenna capacity plays an important part in the tuning and it is this that causes your signals to swing in and out.

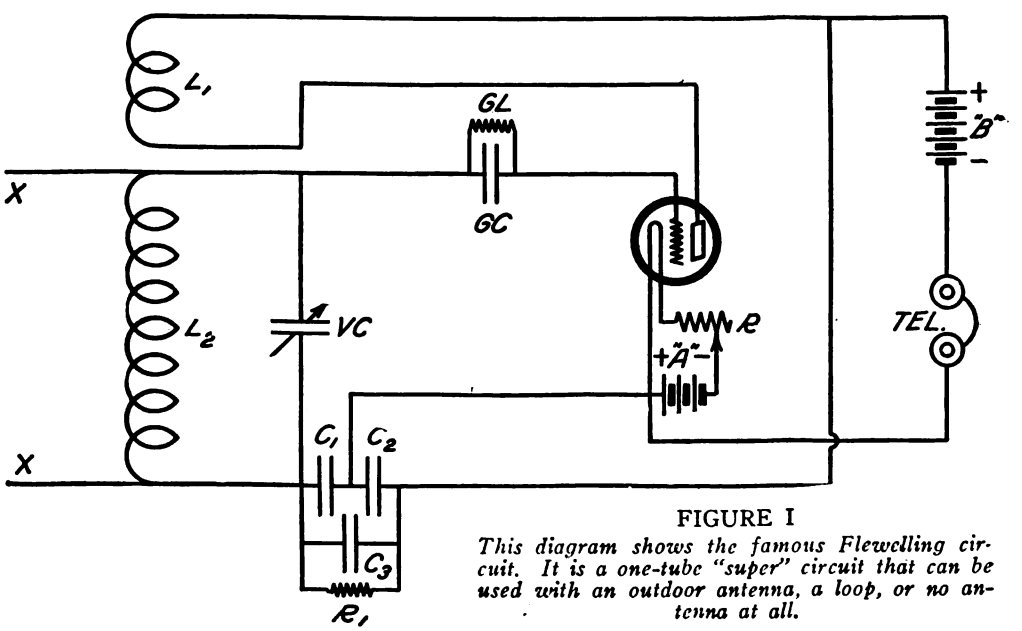

FIGURE I

This diagram shows the famous Flewelling circuit. It is a one-tube "super" circuit that can be used with an outdoor antenna, a loop, or no antenna at all.

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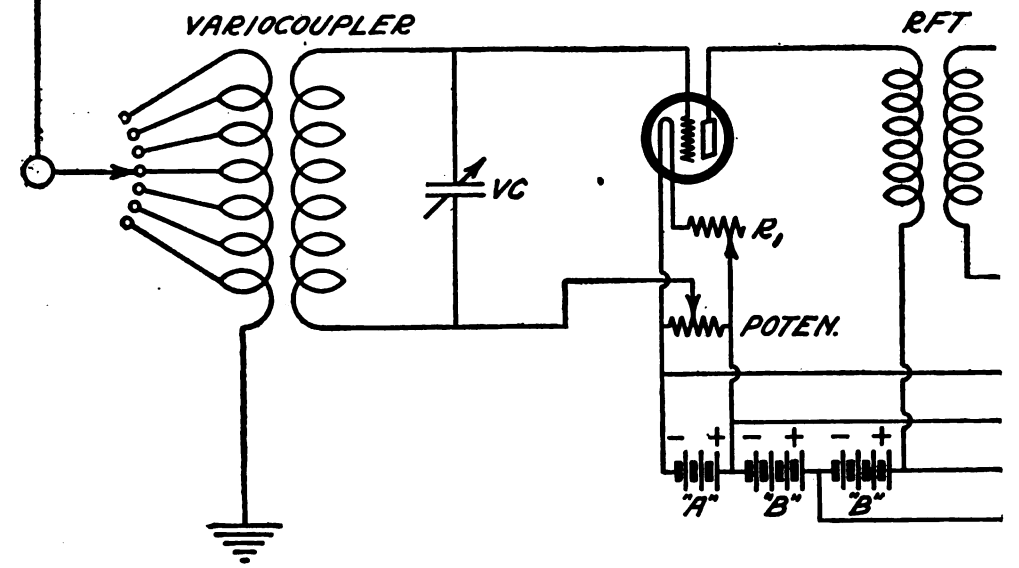
FIGURE 2

A hook-up for two stages of radio frequency amplification used with a crystal detector. By means of the two potentiometer stabilizers the circuit may be made extremely sensitive to DX signals.



QUESTION: I have bought the following apparatus and would like to get a circuit for two stages of radio frequency amplification with a tube detector:

2 Cunningham C-301 vacuum tubes.

1 Cunningham C-300 vacuum tube (for detector).

1 variable condenser, 43 plate.

1 Atwater-Kent variocoupler.

1 Dubilier grid leak and condenser combination.

1 pair of Brandes headphones.

2 Murad radio frequency transformers (for first and second stages).

Is there anything else I will need to have?

ROSCOE B. NETTE

ANSWER: The hook-up for your apparatus will be found in Figure 2. You will need also three filament rheostats, two potentiometers (200 to 300 ohms), three tube sockets, "A" and "B" batteries, and one fixed telephone condenser. If properly connected this set will bring in distant signals, but if you use a loudspeaker you should add to it two stages of audio frequency amplification.

* * *

QUESTION: I would like to get a diagram that shows how to hook up a standard regenerative circuit that uses a variocoupler, two variometers and a series condenser in the antenna circuit, with two stages of audio frequency amplification. I want to use jacks in each stage so that I can use the set with the detector alone, or with either one stage or two stages of amplification.

ARTHUR NILSON

ANSWER: You will find this circuit given on page 210, Figure 3, in the November (1922) issue of POPULAR RADIO. This circuit has met with great favor among radio men; if you use the list of instruments given on the same page as the diagram, you will have good results in long-distance reception.

* * *

QUESTION: Will a potentiometer help me in regulating the "B" battery potential on my detector tube? How many ohms should it have? How should it be connected?

LAWRENCE VRELAND

ANSWER: This will be a good addition to your receiving set. It should be one of at least 200 ohms and should be connected directly across the "A" battery with its pointer connected to the negative terminal of the "B" battery. By rotating the lever arm a variation of six volts can be made in the potential of the "B" battery.

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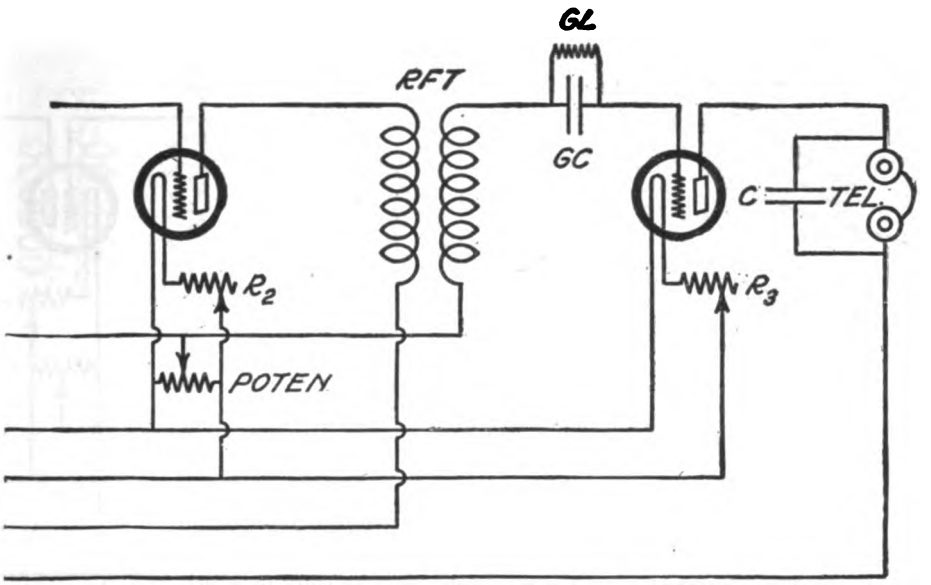

QUESTION: I have the following radio parts:

1 variocoupler
1 variometer
1 variable condenser, .001 mfd.
1 variable condenser, .0001 (vernier)
1 grid leak, 2 megs.
1 grid condenser, .00025 mfd.
1 telephone condenser
2 potentiometers, each 200 ohms

Will you give me a good regenerative hook-up for them?

T. E. REDMOND

ANSWER: The hook-up for connecting your instruments is shown in Figure 3. The two potentiometers are shown as P1 and P2, the grid leak and condenser as GL and GC, the large and small variable condensers as VC1 and VC2, and the variometer and telephone condenser as VAR, and C, respectively.

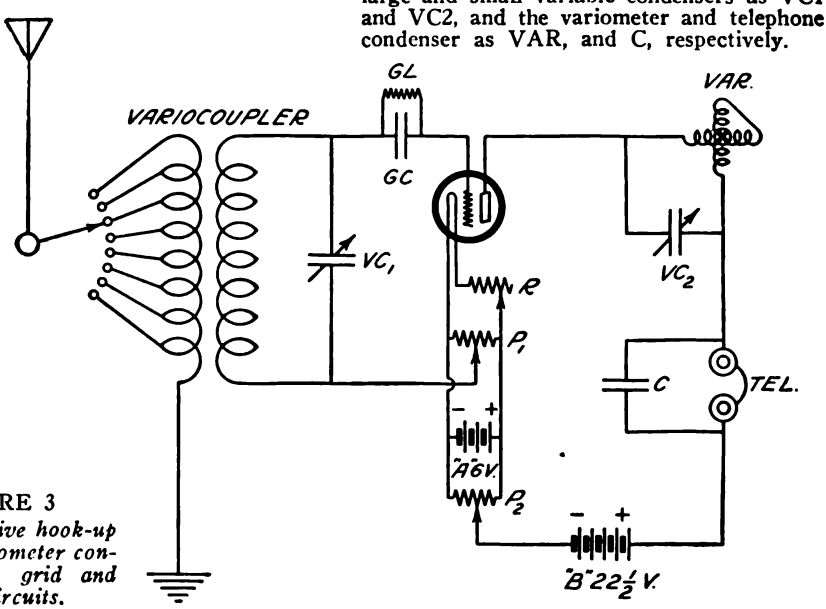

FIGURE 3
A regenerative hook-up with potentiometer control of the grid and plate circuits.

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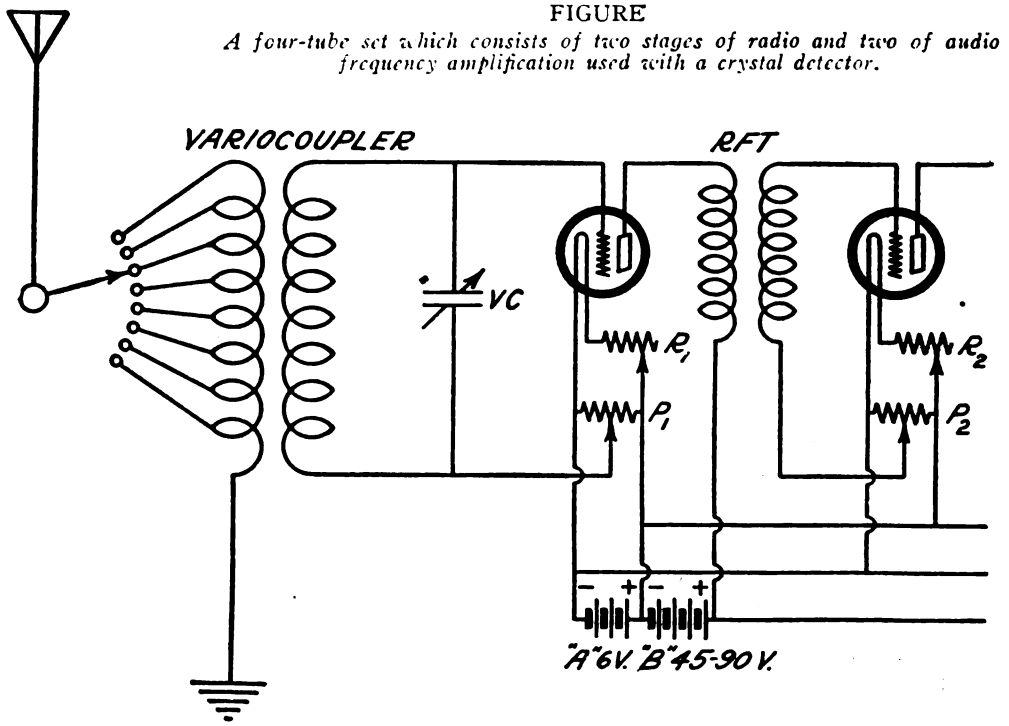
FIGURE

A four-tube set which consists of two stages of radio and two of audio frequency amplification used with a crystal detector.



QUESTION: Please give me a diagram for two stages of radio frequency amplification, crystal detector and two stages of audio frequency amplification. I would like to use a crystal detector, as it would cut down the number of tubes I have to use. I have some crystals that are sensitive over their whole surface and believe they would work if I had the proper circuit

SAM NEWBERRY

ANSWER: The hook-up you need is shown in Figure 4. The radio frequency transformers are designated as RFT, and the audio frequency transformers as AFT. Two potentiometers, P1 and P2 will be required, and these should have a resistance of 200 ohms each. The filament rheostats R1, R2, R3 and R4 are of five or six ohms each. The telephone condenser C should be of approximately .001 mfd. capacity.

* * *

QUESTION: What is the difference between a regenerative set and a non-regenerative set? How can a regenerative set be constructed out of a non-regenerative set?

C. PEARSON

ANSWER: A regenerative set is one in which part of the received and amplified energy is fed back into the input circuit of the vacuum tube and regenerated or reamplified by passing again through the vacuum tube. In a non-regenerative receiver this is not so, the signals entering the input circuit only once. To make a regenerative receiver out of a non-regenerative receiver, insert a variometer in the plate circuit of the detector vacuum tube, so that the plate circuit may be tuned to approximately the same wavelength as the input circuit. Then part of the energy flowing in the plate circuit will be fed back into the input circuit, and the amount of this feedback may be controlled by turning the knob attached to the variometer.

* * *

QUESTION: On page 119 of the June issue of POPULAR RADIO you show a type of antenna called a loop antenna. I would like to know the dimensions of such an antenna.

W. H. MORRIS

ANSWER: We would advise you to build a square type loop. It should have a length of 3 feet to a side. For listening to broadcasting on 360 meters you should wind it with at least 15 turns of solid copper wire, bare or insulated, spaced ¼ inch between turns. Tuning will be accomplished by connecting a variable condenser across the loop.

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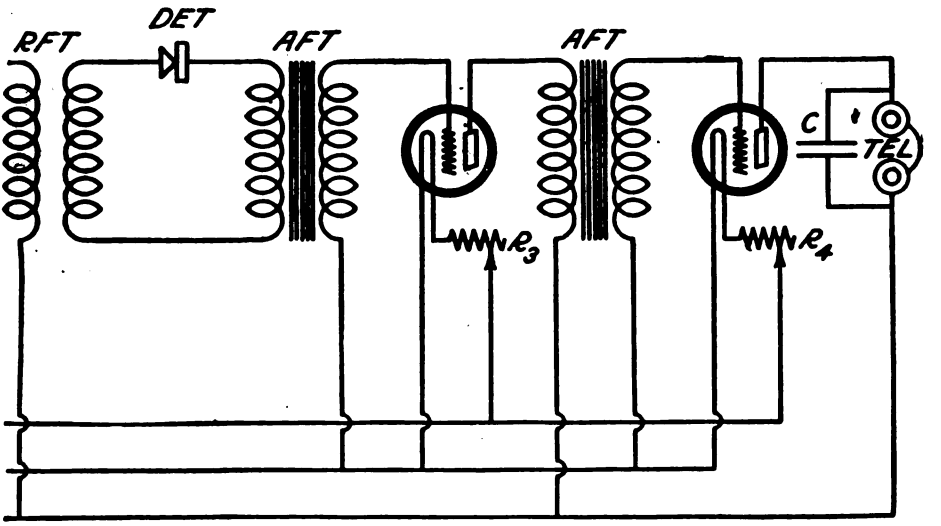

QUESTION: Is it better to use the small or the large type of "B" batteries?

E. S. T.

ANSWER: If you have a single-tube set the ampere-hour capacity of the small type will be sufficient. If you use more than one tube with amplifiers it would be advisable to use the larger type, especially if you use more than 45 volts on one plate of the amplifier tubes.

* * *

QUESTION: I have a crystal detector set that consists of a variocoupler, a variable condenser, a crystal detector, a telephone condenser and a pair of telephones. Kindly show me how to add a variometer and a vacuum tube to it so that it will be regenerative. I would also like to keep the crystal so that I can switch to either crystal or vacuum tube.

ELINOR ROBINSON

ANSWER: The circuit shown in Figure 5 will give the results you require. You will, of course, require an "A" battery of six volts for the filament of the tube, and a "B" battery of 22½ volts for the plate. The switch shown in the diagram should be closed when using crystal and open when using the vacuum tube. When the crystal is being used, the filament of the vacuum tube should not be lit.

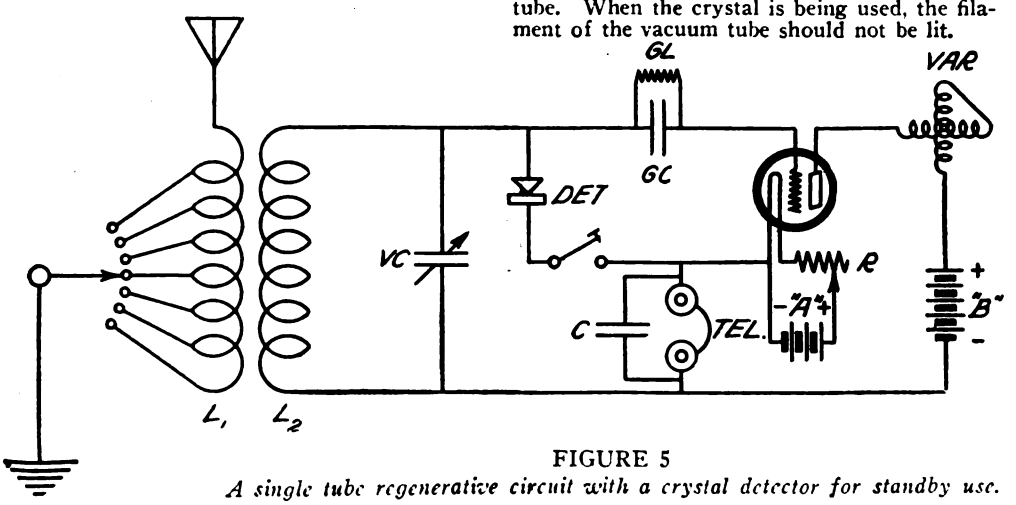

FIGURE 5

A single tube regenerative circuit with a crystal detector for standby use.

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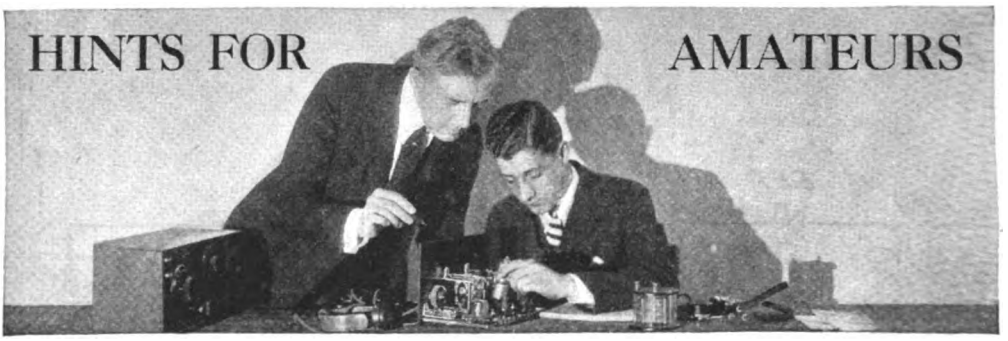

If you see a diagram and read a description of a radio set in a book and decide to build such a set, be sure to follow out every detail of construction. You may be sure that the design of the set has been carefully worked out and that the set has been tested before the description has been put into print.

Many novices try out a hook-up and build a set but use parts other than specified; when they get inferior results they blame it on the set. As a matter of fact they themselves are usually at fault. If you decide to follow instructions for this purpose, follow them down to the last detail; even then, if your success is not as great as you had hoped for, you may be sure that you have overlooked some detail which may have been all-important.

* * *

The ordinary telephone ear-piece is not suitable for use in a radio receiving set because its resistance is too low. To be most efficient a receiver should have a total resistance (impedance) equal to the circuit which is feeding it current. The resistance of the telephones that are used in radio vary from 2,000 to 8,000 ohms. The average resistance in the majority of makes is 3,000 ohms.

* * *

The lead-in for a radio installation should not be run at any great length through the interior of a building, as this will weaken the received energy on account of absorption by the building structure.

* * *

While listening-in to broadcasting, do not allow the detector in a regenerative-circuit receiver to oscillate. You can easily determine if it is oscillating by the high-pitched, whistling sound in your head telephones.

If a set is allowed to oscillate it will send out into space, *via* the antenna, a small quantity of radio energy that will cause the same sort of whistling noise

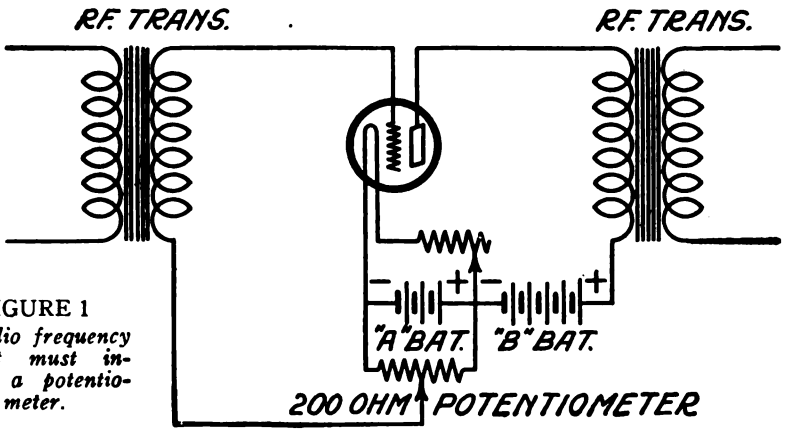

FIGURE 1
A radio frequency circuit must include a potentiometer.

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in your neighbors' sets that you hear in your own telephones. There is no excuse, for anybody who knows this fact, for causing this radiation from regenerative receivers, as it will always be evident to the person who operates the receiver whether or not his set is oscillating.

* * *

WHEN experimenting with the radio frequency amplifier, the amateur should keep in mind the fact that the vacuum tube is a potentially operated device; that is, it is caused to function by the voltage applied to the grid. The grid should therefore be kept at a correct potential so that any incoming voltages that are impressed upon it make the greatest response in the plate circuit. This is most easily done by the use of a potentiometer shunted across the "A" battery. The adjustable pointer of the potentiometer allows this critical voltage to be applied to the grid with ease. A picture of a potentiometer is shown on this page, and the method of connecting it to the radio frequency amplifier is shown in Figure 1. Without this, the amplifier will be sure to function inefficiently.

* * *

WHEN the amateur builds his tickler feed-back circuit receiver he sometimes has trouble getting the set to oscillate. This trouble may be easily overcome by reversing the terminals of the tickler coil, as this is the fault most usually made. To find out which way to connect the tickler coil, tune in a signal the best you can; then reverse the terminals and retune the same signal. The comparison between the two strengths of the signals will give you the answer.

* * *

GOOD reception does not mean noise. A man may have a set that can be heard all over the neighborhood, but what good is mere volume of sound if it is incomprehensible? The two prime requisites of a good receiver are:

That it should tune sharply to eliminate interference.

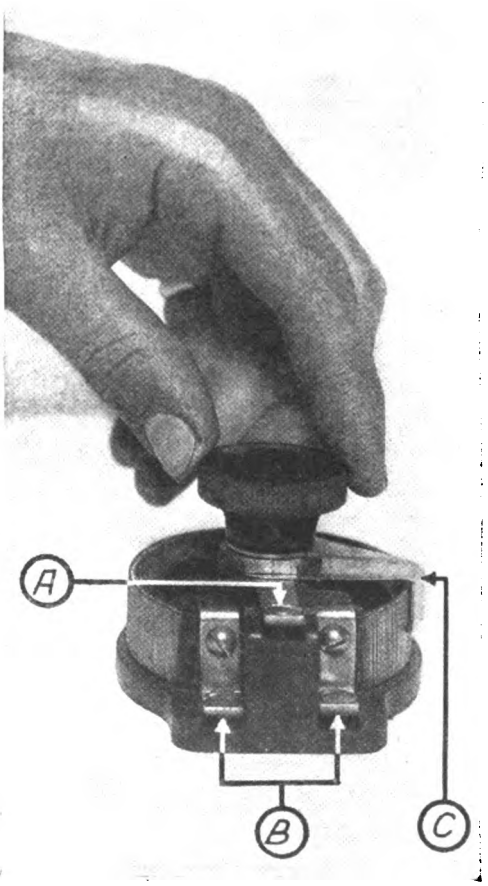
That it should reproduce signals with clarity and truthfulness.

A set that tunes in a signal and can be heard with comfort in a room with a loudspeaker and that can be clearly understood, is valuable, whereas a set that produces strident discords is useless.

When you buy your set, make sure that it will tune sharply and give a clear signal.

* * *

REMEMBER that the positive terminal of your "B" battery goes to the plate of the vacuum tube.



HOW TO CONNECT THE POTENTIOMETER

The terminal A (attached to the lever C) is connected in the grid circuit. The two terminals B are connected across the "A" battery.

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ITEMS *of general interest that you ought to know; bits of useful information that every radio fan ought to know.*

Will We Get Radio Signals from the Spirit World?

THE possibility of establishing contact with the world of the dead by means of radio continues to absorb the interest of the spiritualists. Sir Arthur Conan Doyle has recently delved into the subject and announced the following conclusions:

"Wireless takes us into an etheric region, and it is our provisional belief that psychic life is also on an etheric level and expressed in etheric terms. Therefore, I think there is great hope that wireless, possibly on a far longer wavelength, 30,000 meters say, may give us wonderful results. Several important experiments are progressing along this line."

* * *

The First Press Photograph Is Sent by Radio

THE invention of C. Francis Jenkins for transmitting and receiving pictures by radio (described in the April number of POPULAR RADIO) was given its most impressive practical test on March 3, when a photograph of President Harding was sent from the Naval Radio Station, NOF, in Washington, D. C., and was received at the station of the *Evening Bulletin* in Philadelphia. The picture was transmitted on a wavelength of 1,150 meters.

* * *

Amateur Sentinels in the Ether

IN ORDER to co-operate with Uncle Sam in protecting radio, amateurs of the American Radio Relay League propose to appoint observing stations which will listen in and will log all interference that they hear. The information that they collect will be of help to the government in its determination to get after that peculiarly annoying radio nuisance —the station that insists upon "parking" on the wrong wavelength.

* * *

1,000 Voices Are Broadcast at Once

A RECORD of largest volume of human voices ever broadcast at one time was recently established when station WGY successfully transmitted the singing of the Albany Community Chorus, which is made up of 1,000 men and women.

A College Education at Home—by Radio

STILL another college is testing the possibilities of radio as a means of getting education to the public. The faculty of Marietta College in Ohio, has decided to broadcast a full set of its courses and to give regular credit toward a degree for courses taken in this way. It will be necessary for the radio student to register in the usual way, but aside from that he need not go from his own house.

* * *

Radio Enters a Stockholders' Meeting

THE first use of radio for reporting the proceedings of an important business meeting was made in Chicago on February 27, when the annual gathering of the stockholders of the Commonwealth Edison Company was broadcast for the benefit of the 25,000 owners and 600,000 customers of the concern. One stockholder who listened in on a small crystal set expressed surprise at the ease with which a $20,000,000 increase in capitalization was voted!

* * *

Radio on the Trail of a Dead Language

SCIENTISTS engaged in the study of Mayan, the prehistoric language of Mexico, found unexpected help in the new radio instrument, the pallophotophone, that makes photograph film records of sound. Dr. William Gates, Director of the National Museum of Guatemala, found an Indian who spoke Quiche, which is a direct offshoot of Mayan. He took him to Washington, where he made kymagraph tracings of his voice. Then he discovered that the pallophotophone could catch vibrations which the kymagraph could not possibly record. The Indian has gone back to his mountain home, but the records of his speech are still being studied. Already the scientists have discovered that Quiche is a tone language, akin to Chinese.

* * *

Radio Makes Song Birds Sing

ONE of the most remarkable concerts ever given occurred recently when the Detroit station WWJ put six canaries in front of its transmitter and made them sing—and sing on schedule time, at that! A microphone was placed in front of the cages, which were not

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moved from the accustomed positions. When the program was scheduled to begin a few notes were sounded on the piano, and the tiny artists at once burst into melody.

"We have a canary," wrote in one fan, "that did not know it could sing until WWJ began. He looked into the loudspeaker, twisted his head from side to side, and then started out."

* * *

Radio Warnings from the Jack Frost Country

THREE radio weather stations are to be set up in the MacKenzie Valley this summer by the Canadian Government. The MacKenzie Valley, Siberia, and Greenland are the three great cold centers of the world. One of the difficulties in predicting weather in the past has been the virtual impossibility of obtaining more or less simultaneous weather information from all sections of the earth, particularly from these three frigid areas.

* * *

John Bull Picks Up Yankee Jazz on an Indoor Loop Aerial

LISTENING for signals from American stations is an all-night job in England. Yet during the last few months station WGY in Schenectady has been flooded with letters from English fans who have picked up its broadcast programs. Perhaps the most remarkable instance of long-distance reception of this station is furnished by Captain Round, who heard the American station on a two-foot loop aerial. The Englishmen who listen for American stations have to be real enthusiasts; WGY's program, for example, starts at 7:45 in the evening—12:45 in the morning in London!

* * *

Radio Required on Airships

THE Commissioner of Air Traffic of Denmark has recently made a ruling that all airplanes operating in passenger service must carry radio apparatus as part of their equipment for emergency. This ruling extends the general custom of requiring ships to be so provided as a means of saving life.

* * *

Commands from an Invisible Drillmaster

THE feature of the U. S. Naval Academy's gymnkhana at Annapolis this year was a drill conducted by commands issued *via* radio. The midshipmen who made up the drill team wore the Ku Klux costume, but in each conical helmet was installed a small receiving set. While the spectators could hear no sound, the midshipmen went through their paces in their usual perfect unison.

* * *

A Combination Letter-and-Radiogram

THE postman and the radio operator now work together in a new system of communication that combines postal and radio service between France and her colonies. A letter may now be sent by mail to a radio station, transmitted to a receiving station in the colony, and from there sent by mail again to its destination—at a cost of only the postage at both ends plus two-thirds of the regular radio charge.

* * *

A Radio Wave That Rings a Bell

GERMAN scientists, experimenting with the tendency of radio waves to follow telegraph and telephone wires, announce an invention that enables a transmitting station to call by means of a bell some individual receiving station or group of stations. It is not inconceivable that "answering the radiophone bell" will be included among the duties of the housemaid.

* * *

Uncle Sam's Mail by Radio

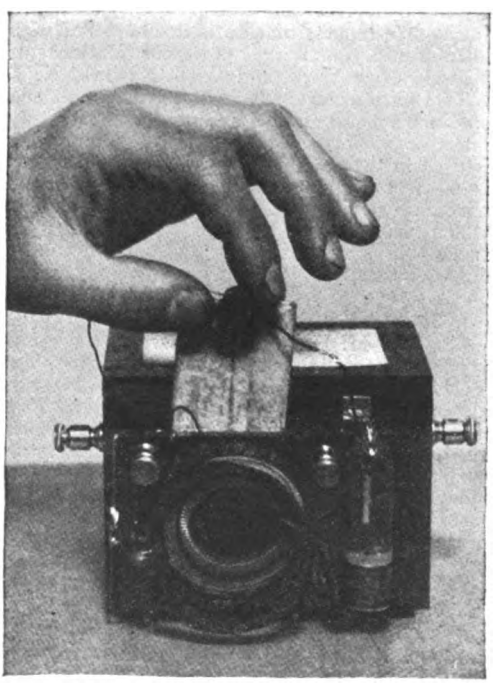
SIXTEEN radio stations are now in operation by the U. S. Post Office Department to aid the Air Mail-Service.

* * *

Gaston Blocks Fritz in the Ether

THE ancient grudge between France and Germany, having recently been settled on land, sea and in the air, is now being fought out in the ether. When a broadcasting station near Berlin recently started to send out news about the Ruhr situation, the Eiffel Tower station in Paris sent out such a long-continued howl as to prompt a Dutch newspaper to observe naively that "it must have been done purposely!"

* * *



ONE OF THE SMALLEST TUBE SETS IN THE WORLD

Some idea of its compactness is gained from the fact that the peanut tube is held in place by its grid condenser and the filament rheostat is concentric to the tuning inductance. It was made by a New York amateur, Frederic W. Proctor.

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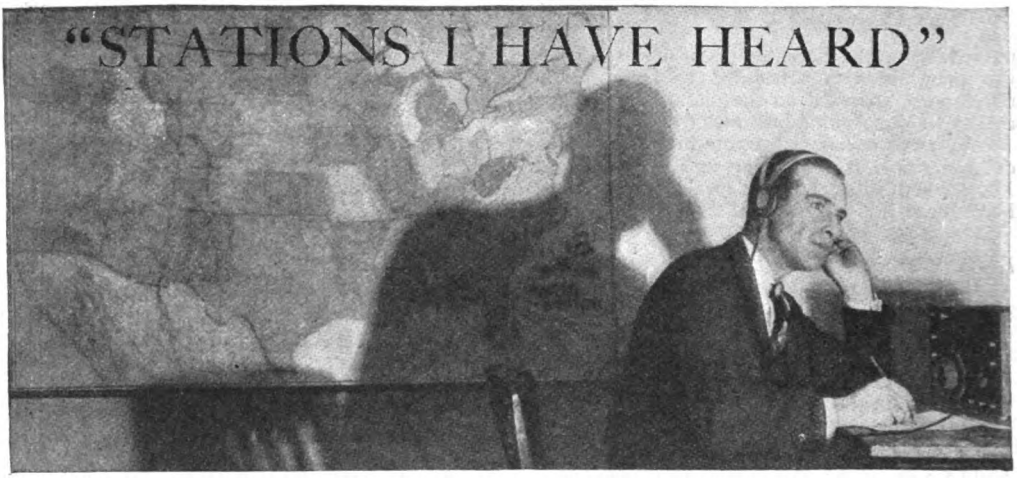

IF *you are getting good results with your receiving set, tell your fellow-readers of* POPULAR RADIO *how you get them. Give the call letters of the stations you hear, the locations of them, the type of apparatus that you are using and* HOW YOU ARE USING IT.

HE USES THE FORBIDDEN THIRD STAGE OF AUDIO FREQUENCY

THE often forbidden third stage of audio frequency in connection with one stage of radio frequency amplification is used by Carl C. Raymond of New York to pick up Davenport, Iowa. He reports that he is not bothered with interference from the powerful stations of WEAF, New York, and WJZ, Newark, N. J.

Two variometers, one in the grid circuit and one in the plate circuit, are used with a highly selective variocoupler. A variable condenser is used in the antenna circuit. The aerial used is 40 feet high and 160 feet long, with two wires. It points in the direction of Davenport, which accounts in a large measure for its success in picking up that station and tuning out the others.

* * *

REMARKABLE RANGE OF A CRYSTAL SET

STANLEY M. HADLEY, who lives in the country near Danville, Ind., says he can hear New York and Atlanta, Ga., on cold nights with almost nothing but a crystal and "a little perseverence." The only item in his set which he considers worth mentioning is his loose coupler, which he carefully soldered and mounted on hard rubber. He also hears Kansas City, Mo., Schenectady, N. Y., as well as nearer stations.

* * *

THIS FAN PREFERS HONEYCOMB COILS

A PERFECTLY good two-variometer set was scrapped to make room for honeycomb coils by Arthur F. Dearborn of Elizabeth, N. J., with surprising results. His record with the variometers was a faint whisper from PWX at Havana; now he hears from St. Louis, Mo., Chicago, Ill., and Davenport, Iowa, with one tube.

Even with a variocoupler helping the variometers, they were not improved to any considerable extent, he insists. He is now using three honeycomb coils: primary, 25 turns; secondary, 35; tickler, 75. A 43-plate condenser is used across the primary and a 23-plate across the secondary. His aerial consists of one wire 110 feet long, strung 35 feet above the ground.

* * *

A TIN ROOF DOES NOT HANDICAP THIS SET

ONE dry-cell tube brings KYW, Chicago, to R. N. Trueman, of Brooklyn, N. Y., in spite of a tin roof and a long lead-in. He uses a variocoupler and one variometer.

His antenna is a single wire about fifty feet high at one end, but it runs down almost to the ground in order to gain its length of 110 feet. For almost half its length it runs six feet from the tin roof. The lead-in runs for forty feet inside the building, held about an inch from the walls by means of glass insulators.

Chicago is heard distinctly, he says, although his instruments are mounted temporarily on a board, and are not shielded from the capacity effects of his hands. Nearer stations are received loud and clear, although the powerful stations of New York and Newark, N. J., are somewhat hard to tune out.

* * *

HE VISITS 13 STATES *VIA* ETHER

A RECORD of hearing 42 stations in thirteen states during his first two months of listening-in is reported by James A. White, of Cincinnati, O. He uses one storage battery tube and no amplification. His list includes WJZ, Newark, N. J., WGM, Atlanta, Ga.; WLK, Minneapolis, Minn.; WBAP, Fort Worth, Tex., and WNAC, Boston, Mass.

White uses a single-circuit regenerative hook-up with an aerial 120 feet long, strung at an average height of 40 feet above the ground.

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HALF A CONTINENT ON A SINGLE TUBE

A TOTAL of 66 stations heard with one tube is the modest report of L. S. Hoskins of Rome, N. Y., who made the "Real DX Regenerative Receiver" designed by Laurence M. Cockaday for POPULAR RADIO and described in the January, 1923, number.

"I have never been stumped yet," writes Hoskins. "I can find something any time of the day. Whenever I find a good program, I put it on my loudspeaker through my other two tubes, rather than hunt for distant stations. Before I made the regenerative set I had heard only 13 stations. The rest of the 66 I caught in three weeks with my new machine."

His station log includes:

WAAF	Chicago
WAAK	Milwaukee, Wis.
WAAM	Newark, N. J.
WAAY	Youngstown, Ohio
WBAK	Harrisburg, Pa.
WBAN	Paterson, N. J.
WBAP	Ft. Worth, Texas
WBS	Newark, N. J.
WBT	Charlotte, N. C.
WBZ	Springfield, Mass.
CFCF	Montreal, Canada
CFCA	Toronto, Canada
WCAB	Newburg, N. Y.
WCAE	Pittsburgh, Pa.
WCAU	Philadelphia, Pa.
WCK	St. Louis, Mo.
WCX	Detroit, Mich.
WDAF	Kansas City, Mo.
WDAJ	Atlanta, Ga.
WDAL	Jacksonville, Fla.
WDAP	Chicago
WEAF	New York City
WFAF	Poughkeepsie, N. Y.
WFAG	Waterford, N. Y.
WFI	Philadelphia, Pa.
WGI	Medford Hillside, Mass.
WGL	Philadelphia, Pa.
WGM	Atlanta, Ga.
WGR	Buffalo, N. Y.
KOP	Detroit, Mich.
KSD	St. Louis, Mo.
KYW	Chicago
WLAG	Minneapolis, Minn.
WLAK	Bellows Falls, Vt.
WLK	Indianapolis, Ind.
WLW	Cincinnati, Ohio
WMAQ	Chicago, Ill.
WNAC	Boston, Mass.
WNAT	Philadelphia, Pa.
NOF	Anacostia, D. C.
WOC	Davenport, Iowa
WOH	Indianapolis, Ind.
WOO	Philadelphia, Pa.
WOQ	Kansas City, Mo.
WOR	Newark, N. J.
PWX	Havana, Cuba
WQAA	Parkersburg, Pa.
WRP	Camden, N. J.
WRW	Tarrytown, N. Y.
WSB	Atlanta, Ga.
WWJ	Detroit, Mich.
WGY	Schenectady, N. Y.
WHAS	Louisville, Ky.
WHB	Kansas City, Mo.
WHK	Cleveland, Ohio
WHN	Ridgewood, L. I.
WHAZ	Troy, N. Y.
WHAM	Rochester, N. Y.
WIAL	Norwood, Ohio
WIAO	Milwaukee, Wis.
WIP	Philadelphia, Pa.
WJAS	Pittsburgh, Pa.
WJAX	Cleveland, Ohio
WJZ	Newark, N. J.
WKAP	Cranston, R. I.
KDKA	East Pittsburgh, Pa.

WHY HE USES AN ANTENNA CONDENSER

THE chief reason that he hears PWX, Havana, Cuba, six times in one month is the use of a variable condenser in his antenna circuit, writes Henry O. Miller, of Philadelphia, Pa.

He has a one-tube regenerative hook-up which does not require a condenser in the antenna circuit, but *with it* he is able to tune out other stations broadcasting on nearly the same wavelengths at the same time. He also hears WDAP, Chicago, and WOC, Davenport, Ia.

* * *

PINE TREES AS AERIAL TOWERS

WITH only one tube Oscar E. Johnson, of Indianapolis, Ind., is able to pick up fifteen to twenty stations almost any night. He uses a small inductance coil shunted by a variable condenser in his plate circuit.

Two pine trees about 100 feet high support his antenna. They are 130 feet apart and stand on the top of a small hill. Two wires are strung between them, with insulators spaced six feet from the nearest branches, and the lead-in is fastened to one end.

* * *

REMARKABLE RESULTS FROM A CRYSTAL SET

USING electric light wires for an aerial and a vacuum tube with his crystal in a reflex circuit, Joseph M. Ambrose hears Chicago in Louisville, Ky. Experimenters seldom go to so much trouble to use a crystal, but Ambrose thinks his set is as good as the ordinary three-tube receiving set.

* * *

HE SPANS THE CONTINENT WITH A LOUDSPEAKER

BROADCAST music from San Francisco comes in clear on the loudspeaker of R. N. Borden, of Pittsburgh, Pa. He uses a regenerative hook-up with two stages of audio frequency and two stages of radio frequency amplification. His aerial is made of two strands of wire 35 feet high and 90 feet long.

* * *

ADVANTAGES OF A SINGLE CIRCUIT

MYRON SELFRIDGE, of Atlanta, Ga., hears practically all of the New York stations with a single circuit tuner, one tube, and a two-wire antenna, 45 feet long.

* * *

RECEIVING LONG-DISTANCE ON A DOOR

UNABLE to erect an antenna on his roof, John A. Spear has made an efficient loop aerial on a door of a clothes closet. He opens or closes the door so that the aerial will point toward the station he wishes to hear, and with two stages of radio frequency amplification he brings New York stations into his Chicago room almost loud enough to operate a loudspeaker.

The aerial is made of 75 feet of the ordinary seven-strand antenna wire for sale at most radio stores, and is held about an inch from the door by porcelain insulators. His set is grounded on a steam radiator.

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FROM NEW HAMPSHIRE TO CALIFORNIA ON A DETECTOR TUBE

A DETECTOR tube alone, in a single circuit, can reach from Newfields, N. H., to Los Angeles, Calif., according to Russell Sheehy. He made his set himself, and during the last six months he has heard 144 stations in 38 states, Cuba, Porto Rico and Canada. His record shows 16 stations in New York, 15 in Pennsylvania, eight in Texas and seven in Ohio (and it might be added) one in his own state, New Hampshire.

* * *

A ROCKING-CHAIR TOUR TO SEVENTEEN CITIES

DAVID R. NEWMAN of Hoboken, N. J., submits his distance record for one evening of rocking-chair traveling, and sets down the time when he arrived at 17 different cities, using one dry-cell tube and a crystal detector in a reflex circuit. His list is:

7:18	WDAP	Chicago
7:21	WJZ	Newark, N. J.
7:33	WDAL	Jacksonville, Fla.
7:39	WFI	Philadelphia, Pa.
7:52	WEAF	New York City
7:57	WOC	Davenport, Ia.
8:07	WCAE	Pittsburgh, Pa.
8:18	WSB	Atlanta, Ga.
8:22	WHN	Ridgewood, N. Y.
8:30	WWJ	Detroit, Mich.
8:39	WHAS	Louisville, Ky.
8:52	WGY	Schenectady, N. Y.
8:54	CFCA	Toronto, Canada
8:57	WGR	Buffalo, N. Y.
9:08	WJAX	Cleveland, O.
9:17	WCK	St. Louis, Mo.
9:21	WOQ	Kansas City, Mo.

Newman used an outdoor antenna made of two strands, 120 feet long, at an average height of 35 feet from the ground.

* * *

LONG DISTANCE ON A CRYSTAL SET

LONG distance work with a crystal set is reported by James A. Jefferson, of South Bend, Ind., who listens in on WJZ, Newark, N. J., and WEAF, New York, almost every clear night. He hears WSB, Atlanta, Ga.; WGY, Schenectady, N. Y.; KDKA, Pittsburgh, Pa.; WWJ, Detroit, Mich.; WOC, Davenport, Ia., and WHB, Kansas City, Mo.

Jefferson is fortunate to have a tower for his antenna, and no landlord to kick about it. The tower is 70 feet high, and his two-wire antenna runs a distance of 125 feet to the roof of his home, which is 40 feet high. In his fifth month of "radio fanning" he is still proud of his loose coupler which he made from directions printed in POPULAR RADIO, and he sees no reason for using more expensive apparatus.

* * *

THIRTY IN TWO NIGHTS

THIRTY stations in two nights is the record of A. H. Bosworth, of Los Angeles, Calif., who uses a regenerative circuit with two stages of amplification. In addition to practically all of the larger stations of the western coast he hears WGM, Atlanta, Ga.; WIP, Philadelphia, Pa.; WBAP., Fort Worth, Tex.; KDYY, Denver, Colo., and a station in Salt Lake City, Utah.

He was satisfied with less than a dozen stations and thought his set was working well when by accident he learned that tuning is a gentle art. Concerning tuning, he says:

"I had heard that a movement of a hundredth of an inch or less would sometimes tune a station in and out, but had no idea that my own set was so sensitive until experience forced this upon me. Since then, I have acquired a more gentle touch and a great respect for the man who can really tune his set."

* * *

A LONG-DISTANCE BED

NEXT to the magic carpet comes the enchanted bedsprings as a means of traveling through the air from one city to another. Several have told of their exploits with this new antenna, notably A. R. Goldberg, of New York, who, in the third story of a seven-story apartment house, hears Pittsburgh, Pa., with but one tube.

A range of two or three hundred miles is not infrequent with such a combination, as it is often quite as good as an indoor loop or one of the plugs made to fit in a light socket.

* * *

TWO STAGES OF AMPLIFICATION COVER THE UNITED STATES

Two stages of audio frequency amplification have covered the United States for L. M. Stephenson, of Phoenix, Ariz., when used with a regenerative hook-up of the two-variometer type. A variable condenser is used across the secondary coil of the variocoupler with another in the antenna circuit, and these are highly praised by Stephenson for their help in delicately tuning-in distant stations. An outstanding feature of the set is the large number of combinations which can be used for tuning to any particular station. When one station interferes, it is almost always possible to shift the dials to new positions, where the interference diappears.

Among the stations he has heard are WEAF, New York, WSB, Atlanta, Ga., KYW, Chicago, KFAF, Denver, KZN, Salt Lake City, KFDB, San Francisco, and KYG, Portland, Ore.

* * *

HE INCREASED HIS RANGE WITH A WOODEN VARIOMETER SHAFT

THE operator who gets down to the fine points of tuning is constantly hunting for "stray capacity," such as that caused when the human body comes close to a receiving set, and Walter E. Jacket, of San Francisco, has happily discovered the drawback of a metal variometer shaft.

He first mounted his variometer four inches behind the panel of his set, to keep it farther away from his hand while he was tuning. This helped a little, but to make a good job he cut out a piece of the metal shaft and inserted a small rod of wood. His range was increased from 200 to 2,000 miles. He used to hear only local stations, but now he hears Chicago stations, as well as practically all of the stations on the Western coast.

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"WORKRITE"

180° SUPER VARIOCOUPLER

$3.50

One of these WorkRite 180° Super Variocouplers made from moulded Bakelite and two WorkRite Super Variometers made from mahogany make up the "WorkRite Tuner Team"—the most selective circuit possible.

A year ago the price of these instruments was $6.00 each. Due to our enormous production you can now buy them for $3.50 each. Order a set today. And remember that

WORKRITE RADIO PARTS WORKRITE

THE WORKRITE MANUFACTURING CO.

(Branch Office, 2204 Michigan Ave., Chicago) 5509 Euclid Avenue, Cleveland, Ohio

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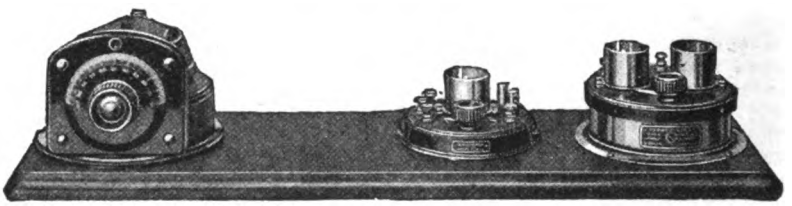
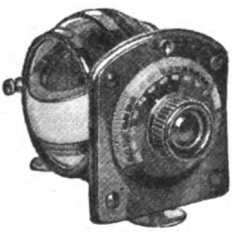
ATWATER KENT

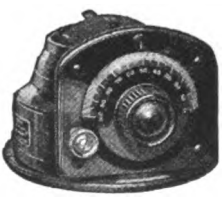
Receiving Sets and Parts



Complete Set, consisting of Coupled Circuit Tuner, Detector Unit and 2-stage Amplifier



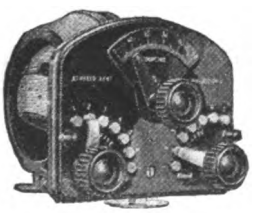
Mounted Variometer



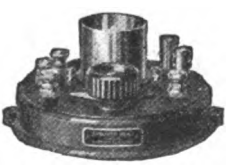
Type 11 Tuner

TAKE the world with you this summer wherever you go. On your automobile and yachting trips, to your camp, or your cottage at the shore or in the mountains. An ATWATER KENT radio set will bring you music, reports, time signals, baseball scores—the world's news.

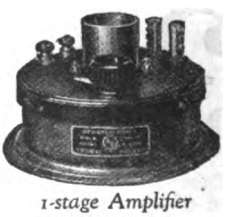
Atwater Kent products sell on appearance.



Mounted Variocoupler



Detector Unit



1-stage Amplifier

ATWATER KENT MANUFACTURING COMPANY

4933 STENTON AVE. *Radio Dept.* PHILADELPHIA, PA.

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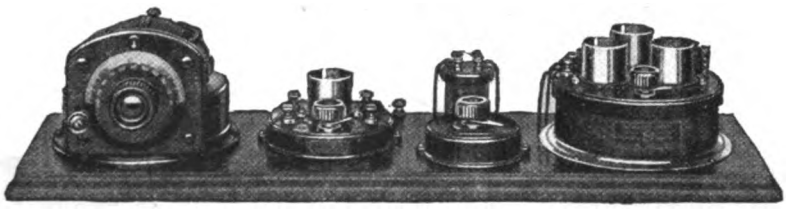
ATWATER KENT

Receiving Sets and Parts



Complete Set, consisting of Type 11 Tuner, one stage of Radio Frequency Amplification, and Detector 2-stage Audio Frequency Amplifier

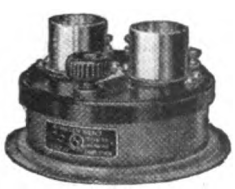
ATWATER KENT sets and parts are ideal for summer use due to their compact and rugged construction and the fact that they are moisture-proof. They are made mostly of condensite with all metal parts thoroughly water-proofed.

You will find ATWATER KENT radio equipment ideal for summer use.

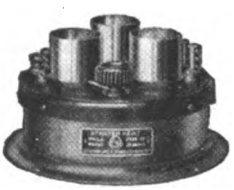
They stay sold on quality of performance.

R. F. Transformer

Standard Vac. Tube Unit



2-stage Amplifier. A similar unit is furnished in a Detector 1-stage Amplifier



Detector 2-stage Amplifier

Potentiometer
Also made for panel mtg.

ATWATER KENT MANUFACTURING COMPANY

4933 STENTON AVE. *Radio Dept.* PHILADELPHIA, PA.

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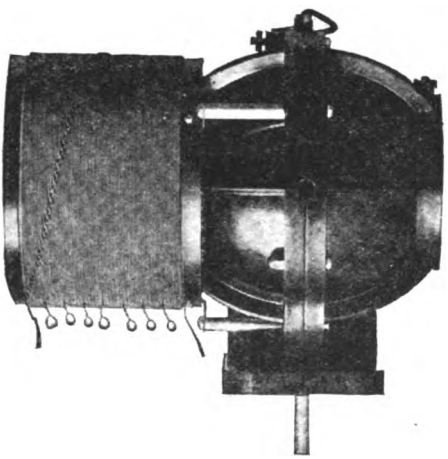
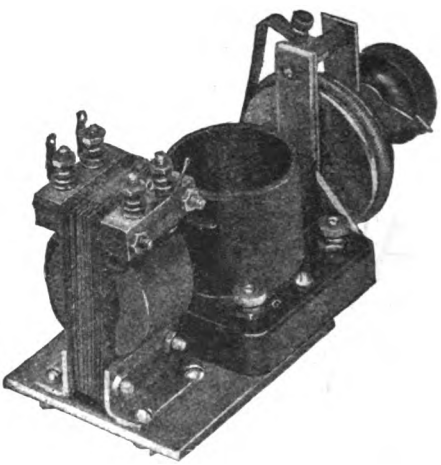
SE-AR-DE

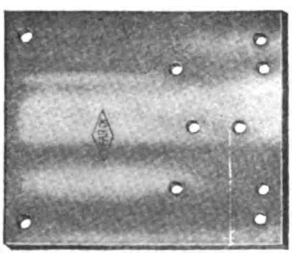


No. 165.....$13.00
SE-AR-DE RADIOMETER WITH
B. W. INDUCTANCE

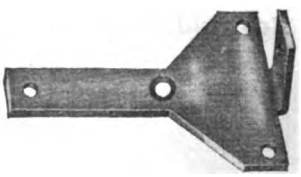


No. 197 AMPLIFYING UNIT.....$10.50
FEDERAL TRANS.

No. 198 AMPLIFYING UNIT.....$7.50
ACME TRANS.



No. 196 TRANSFORMER MOUNTING
PLATE.....$0.10



No. 195 SOCKET MOUNTING
BRACKET.....$0.15

R. MITCHELL & CO.

255 Atlantic Ave. **Boston, Mass.**

For 47 years Manufacturers of Scientific and other equipment
Look for trade mark on every piece

Jobbers and Dealers write for discounts

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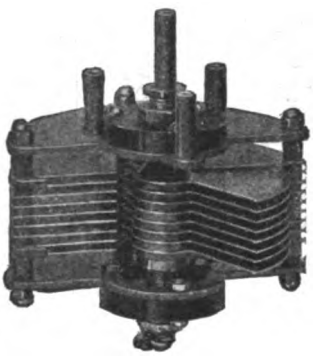
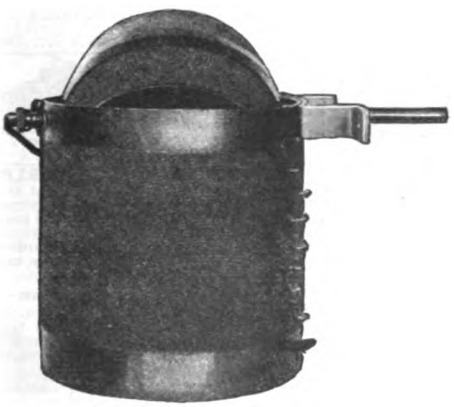
SE-AR-DE

No. 146 RADIOMETER.....$8.00
MOLDED BAKELITE



No. 185 VARIABLE CONDENSER....$4.25
CAP. .00035 M. F. 17 PLATES



No. 167 COUPLER..... ....$5.50

No. 164 KNOB AND DIAL.....$0.75
MOLDED BAKELITE

R. MITCHELL & CO.

255 Atlantic Ave. Boston, Mass.

For 47 years Manufacturers of Scientific and other equipment
Look for trade mark on every piece

Jobbers and Dealers write for discounts

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BUILD YOUR OWN RADIO OUTFIT

HIGH QUALITY GOODS AT LOW PRICES

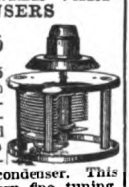
FAST SERVICE—THE PRICES QUOTED DELIVER THE GOODS TO YOUR DOOR

BARAWIK SPECIAL PANEL MOUNTING VARIABLE CONDENSERS

D812—43 plate .001 Mfd. $1.73
D813—21 plate .0005 Mfd. 1.43
D814—11 plate .00025 Mfd. 1.32
D815—3 plate Vernier 98c

These are especially high grade condensers and we guarantee them to be mechanically and electrically perfect. Genuine bakelite end plates of high dielectric and great mechanical strength. Sturdy aluminum alloy plates perfectly spaced to insure smooth, even reliable capacity. Our low prices save you money. These condensers are of the very best make and are not to be compared with any inferior cheap condensers offered. We guarantee them to please you or your money back.

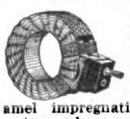
COMBINATION VERNIER VARIABLE CONDENSERS



D824—23 plate .0005 Mfd. Price $2.89
D826—43 plate .001 Mfd. Price 3.45

The latest improvement in condensers consists of regular variable condenser controlled by large knob and dial. Separate small knob mounted above dial controls a three-plate vernier condenser. This arrangement permits of very fine tuning High-grade design and construction. Finely finished. Suitable for panel mounting.

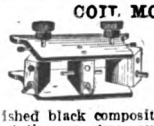
INDUCTANCE "HONEY COMB" COILS



Carefully made — fine looking coils. Highest efficiency. Low distributed capacity effect, low resistance—high self inductance. Very firm enamel impregnation. Range given is in meters when varied with .001 variable condenser. Mounted coils have standard plug mountings.

Turns	Meters	Art. No.	Not Mntd.	Art. No.	Price Mntd.
25	120- 250	D301	$0.39	D320	$0.89
35	175- 450	D302	.42	D322	0.96
50	240- 720	D303	.49	D323	1.04
75	390- 910	D304	.54	D324	1.08
100	500- 1450	D305	.58	D325	1.13
150	600- 2000	D306	.63	D326	1.17
200	900- 2500	D307	.72	D327	1.26
250	1200- 3500	D308	.78	D328	1.35
300	1500- 4500	D309	.82	D329	1.36
400	2000- 5000	D310	.97	D330	1.57
500	2800- 6100	D311	1.12	D331	1.63
600	4000-10000	D312	1.27	D332	1.78
750	5000-12000	D313	1.43	D333	1.93
1000	7900-15000	D314	1.70	D334	2.28
1250	9750-19500	D315	1.92	D335	2.49
1500	14500-26500	D316	2.18	D336	2.65

COIL MOUNTINGS



D340 Three coil mounting $3.95
D341 Two coil mounting 2.95

High grade fine looking mountings. Polished black composition. Center receptacle stationary, two outer ones adjusted by knobs. Takes any standard mounted coil

GALENA DETECTOR

Easy fine adjustment. Crystal mounted in cup. Moulded base and Knob. Brass parts polished nickel finish. **D732** Each 59c

This Guarantee Protects You. Examine the goods we ship you. They must suit you in every respect. If you are not satisfied with your purchase return the goods at once and we will refund the price you paid.

VACUUM TUBES

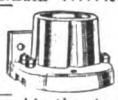
Standard Brands—Cunningham Radiotron. Every one guaranteed new and perfect. We will ship brand in stock unless you specify otherwise.

D105 Detector. Each $4.45
D110 Amplifier VV200 or C300 Each 5.95
D112 Amplifier VV201A or C301A Each 5.95
D115 5 Watt Transmitter 7.70
D107 WD 11 1½ volt 5.95
D109 WD 11 adapter. Each ... 48c

VACUUM TUBE SOCKETS

Our Special Socket. A wonderful value. Moulded entirely of bakelite. Four binding post connections. Right angled contact springs **D140** For Standard Base Tubes. Each 39c
D108 For WD 11 Tubes. Each 49c

PORCELAIN BASE AND TUBE



D144 Crosley for either panel or table mounting for Standard Base ... 36c

High Grade combination type for panel or table mounting. Metal tube. Highly insulated base. For Standard Base Tubes **D146** Each 45c

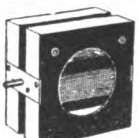
GRID CONDENSER

D162 Mounting holes spaced to fit lugs of above leak Cap. .00025 MF. 14c
D163 Same as 162 but higher grade. Enclosed in metal case. 39c

VARIABLE GRID LEAK

Pencil mark type. Resistance may be varied exactly as needed.
D100 Each 19c

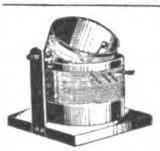
VARIOMETER



D410—Completely assembled, price $2.69 Perfect in design and construction. Accurate wood forms. Correct inductive ratios. Solid baked windings, positive contacts. Highest efficiency.

D411—Not assembled but all parts complete, except wire, including winding form $1.48

VARIO-COUPLER



With this loose coupler and two variometers, together with the necessary other parts, a highly efficient tuning set can be made. Easily mounted on panel. Primary winding on formica tube. Inductively coupled for 180 to 600 meters. Multiple taps permit fine tuning.

D415 Price, completely assembled $2.45
D416 Not assembled, but all parts complete. Price, except wire $1.18
D417 Rotor ball only. Each 29c
D408 Bakelite Stator tube only. Each 35c

RADIO FREQUENCY AMPLIFYING TRANSFORMER

D995 Each $3.95

This transformer will get the long distance stations loud and clear. Permits of easy sharp tuning. Helps cut out static and interference. Makes your set sensitive enough to use a loop aerial. Enclosed in metal case affording perfect shielding. Suitable for panel or base mounting. Because of its special design can be mounted in any V. T. socket. Works with any make of tube. Wave ranges 150 to 550 meters. Wiring diagrams included.

OUR SPECIAL AUDIO FREQUENCY AMPLIFYING TRANSFORMERS

As high as three stages can be used without howling, due to proper impedance ratio, minimum distributed capacity, low core losses and proper insulation. Mounted style has bakelite panel with binding post connections. Unmounted has core and coils assembled with two holes in core for fastening to apparatus.

D234 10 to 1 Mounted. Each $3.48
D235 10 to 1 Unmounted. Each 2.05
D236 3 to 1 Mounted. Each 3.40
D237 3 to 1 Unmounted. Each 2.85

FILAMENT CONTROL RHEOSTATS

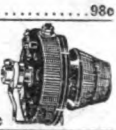
Crosley—Wound on vulcanized fiber. Adjustable to any panel. Complete with knob.
D130 Each 45c

Best grade. High heat resisting base. Diam. 2⅛ in. cap. 1½ amp. Resist. 6 ohms. 1¼ in. Knob with pointer.
D132 Each 45c

POTENTIOMETER

Same style as above rheostat. Gives fine "B" battery adjustment. Resistance 140 ohms.
D133 Each 98c

VERNIER RHEOSTAT



Gives exceedingly fine control of a battery current. A necessity for best receiving results.
D135 Each 78c

PLATE CIRCUIT "B" BATTERIES

You can make real savings on these batteries. Don't pay more. We guarantee them to equal any on the market regardless of price. Absolutely uniform. Extra long life.

D180 Signal Corps type, small size, 15 cells. 22½ volts. Each, 95c.
D184 Variable Large Navy size, 5 taps, giving range from 16½ to 22½ volts in 1½ volt steps. Each $1.80
D188 Combination Tapped 45 volts, 30 cells. 6½x4x6 battery. Tapped to give 45, 22½, 21, 19½, 18, and 16½ volts. Handles both detector and amplifier tubes. Each $3.55

DETECTOR CRYSTALS CAREFULLY TESTED

D736 Galena, Arlington tested, per piece 19c
D738 Silicon, Arlington tested, per piece 19c
D735 Tested, Galena, per piece 9c
D737 Tested, Silicon, per piece 9c

THE BARAWIK CO. 102 S. CANAL STREET CHICAGO, ILL.

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USE BARAWIK STANDARD PARTS

YOU SAVE MONEY WHEN YOU BUY FROM US

FAST SERVICE—THE PRICES QUOTED DELIVER THE GOODS TO YOUR DOOR

SOLID BARE COPPER WIRE

Solid bare copper wire for aerials, leads or wiring instruments.

Solid Bare Copper Wire, size 14
D240—100 ft. coil 49c
D242—500 ft. coil $2.35

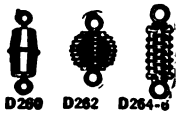
Solid Bare Copper Wire, size 12
D244—100 ft. coil 67c
D245—500 ft. coil $3.05

STRANDED ANTENNA WIRE

Cabled of fine copper strands. Very flexible. High tensile strength. Best for antennas.

D248—100 ft. coil 72c
D249—500 ft. coil $3.20

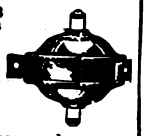
ANTENNA INSULATORS



D260 Size 1x3¼. Two for.....17c
D262 Size 2⅛x3¼. Two for.....55c
D264 Size 1⅛x4. Two for.....69c
D266 Size 1¼x10⅛. Two for $1.28

D260 D262 D264-6

OUTDOOR LIGHTNING ARRESTER



D980 Price.....$1.58
Protect your instruments with this lightning arrester. You cannot afford not to. Weatherproof porcelain case. Air gap type. Permanent. Durable. The most practical quality arrester obtainable. Underwriters approved.

PORCELAIN BASE SWITCHES

Fine white porcelain bases. Copper contacts and blades. Can be used as antenna switches.

D383 Single Pole Single Throw. Each 20c
D383 Single Pole Double Throw. Each 32c
D384 Double Pole Double Throw. Each 50c

SWITCH LEVERS

Moulded composition knob. Exposed metal parts polished, nickel finish. Fitted with panel bushing, spring and two set nuts. A high grade switch.

D380—1" Radius
D381—1¼" Radius } Each
D382—1½" Radius } 19c

SWITCH LEVER STOP

Brass, polished nickel finish.
D386—Dozen 18c. Hundred $1.05

ONE-PIECE DIAL AND KNOB

Moulded of highly polished black composition with clean plain engraved scale and numerals in contrasting white enamel. Ribbed knob to fit the hand. An attractive neat pattern.

D900 2¼" Diam. for 3-16" shaft. Ea..18c
D901 2¼" Diam. for ¼" shaft. Ea.....19c
D904 3" Diam. for 3-16" shaft. Ea.....25c
D905 3" Diam. for ¼" shaft. Ea.....25c
D906 3½" Diam for 3-16" shaft. Ea...35c
D907 3½" Diam. for ¼" shaft. Ea....35c

GUARANTEED QUALITY GOODS

at money saving prices. You can build the parts purchased from us into your set and feel confident of the best results. If what you want is not shown here write us for prices—we have every part for your set ready for quick shipment and the prices are right.

RADIO JACKS AND PLUGS

Finest grade jacks, improved design. Best materials Phosphor bronze springs. Silver contact points. Nickel finish. Mount on panels ⅛ to ⅜ in. thick.

Jacks only
D390 Open circuit. Each.....43c
D391 Closed circuit. Each...49c
D392 Two circuit. Each.....60c
D393 Single-cir. fila. control..69c
D394 Two cir. fila. control..85c

D395 Plug. Large space with set screws for attaching cord. Each.....49c

COMPETITOR JACK AND PLUG

Well made, durable, smooth working. Interchangeable with any standard jacks and Plugs. Solder connections. Nickel finished metal parts.

D387 Open Circuit Jack. Each.....27c
D388 Two Circuit Jack. Each.....35c
D389 Standard Plug. Each.....35c

BINDING POSTS

Brass, polished nickel finish. Washer and 6-32" screw extending ⅝".....
D370 Large size—barrel and knob ¾" long, dozen 85c
D372 Smaller size—barrel and knob 9-16" long.
D370-2 dozen 70c D376-8
D374 Large size with composition knob. dozen 50c
D376 Large size with hole for phone tip or wire, dozen.....80c
D378 Small size with hole for phone tip or wire, dozen.....35c

STORAGE BATTERY

A very high grade battery made especially for radio service. Guaranteed. Properly cared for will give years of service for filament lighting.
D194 6-v., 40 amp. size. Each..$10.00
D196 6-v., 80 amp. size. Each....$12.50
Price does not include transportation.

CABINETS

Fine-looking cabinets solidly built. Made of genuine solid mahogany in elegant hand rubbed finish. You will be proud of your set mounted in one of these cabinets. Hinged tops. Front rabbeted to take panels. Panels not included. Prices are transportation paid.

Panel Size	Inside Dimensions High	Wide	Deep	Art. No.	Price Each
6x 7"	5½"	6½"	7"	D420	$2.48
6x10½"	5½"	10"	7"	D422	2.75
6x14"	5½"	13½"	7"	D424	3.30
7x14"	6½"	13½"	7"	D423	3.60
7x18"	6½"	17½"	7"	D426	3.90
7x21"	5½"	20½"	7"	D425	4.20
9x14"	8½"	13½"	10"	D428	3.70
12x14"	11½"	13½"	10"	D430	4.40
12x21"	11½"	20½"	10"	D432	5.25

SOLID GENUINE CONDENSITE CELERON PANELS

Notice our very low prices in this fine quality grade 10 genuine solid sheet Condensite Celeron (a product with mechanical, chemical and electrical properties like formica and bakelite). Machines well without chipping. Won't warp. Waterproof. Highest mechanical and di-electric strength. Attractive natural polished. Black finish which can be sanded and oiled for extra fine work.

Panel Size	⅛" thick 3-16" thick Art. No.	Price	¼" thick Art. No.	Price	¼" thick Art. No.	Price
6x7	D450	$0.50	D460	$0.75	D470	$0.98
6x10½	D451	.75	D461	1.18	D470	1.47
6x14	D452	1.05	D462	1.55	D472	2.05
7x14	D458	1.20	D468	2.60	D478	2.40
7x18	D453	1.55	D463	2.30	D473	3.10
7x21	D457	1.78	D467	2.65	D477	3.60
9x14	D454	1.60	D464	2.30	D474	3.10
12x14	D455	2.10	D465	3.10	D475	4.15
12x21	D456	3.15	D466	4.65	D476	6.20

HOME CHARGER BATTERY CHARGING RECTIFIER

Charge your battery at home over night for a few cents. Simply connect to any 110 volt 60 cycle light socket, turn on current and rectifier does the rest automatically. Will work for years without attention. Simple connections. Gives a tapering charge which batteries should have. You can make it pay a profit charging your friends' auto batteries. Long connecting cords with pair of battery clips. **Prices are Transportation Paid.**
D201 For 6 volt battery.....$13.95

BARAWIK QUALITY HEADSETS

These headsets have proven on rigid tests to be one of the very best on the market. The tone quality is excellent with an unusual volume. Skilled workmen make them from only the best selected materials. The receiver cases are brass in fine polished nickel finish. Polished black ear pieces. Fabric covered head band comfortably and quickly fitted to the head. Supplied with 5-foot cord. These sets were designed to sell for much higher prices, and at our price are a wonderful bargain. We guarantee that you will be pleased with them and agree that they are the best value by far yet offered. If they don't suit you we will cheerfully return your money.
D770—2000 ohm.....$3.75

OTHER STANDARD BRAND HEADSETS

D751 Murdock 56, 2000 ohm.....$4.20
D752 Murdock 56, 3000 ohm..... 4.95
D764 Frost, 2000 ohm..... 4.20
D766 Frost, 3000 ohm..... 4.85
D756 Red Head, 3000 ohm..... 5.85
D758 Western Electric, 2200 ohm.. 9.50
D754 Baldwin Type C with universal jack plug $12.00
D755 Baldwin Type C unit..... 5.50
D768 Brandes, 2000 ohm..... 6.95

THE BARAWIK CO. 102 S. CANAL STREET CHICAGO, ILL.

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In Philadelphia, Where Radio Enthusiasm Tops the Country, the Biggest Selling Receiver Is the S-P-2!

Distributors for

Lyradion Sales & Eng. Co.
Sleeper Radio Corp.
Jewett Mfg. Corp.
A. B. C.
Pacent Elec. Co.
Schieber & Jensen
Elec. Prod. Mfg.
Penn Radio
Atwater Kent
Homecharger
Radisco
Electrose
Mitchell-Rand
Callophone
Amer. Radio & Research Corp.
Baldwin Radio
Dubilier

WHOLESALE ONLY

The S-P-2 is truly the SUPERIOR RECEIVING SET on the market today and has been proven far and away in a class by itself, excelling any regenerative receiver now offered costing $125.00 to $180.00.

THE LIST PRICE IS BUT $85.00 WITH AN ADDITIONAL CHARGE OF $15.00 FOR THE ADAPTER.

The S-P-2 is a complete Receiver of radio-telephone and radio-telegraph signals over a wavelength range of from 180 to 650 meters, using three tubes, viz.: detector, one stage of radio frequency amplification and one stage of audio frequency amplification.

An Adapter representing an additional stage of audio frequency amplification added to the S-P-2 Receiver AS SIMPLY AS INSERTING A TUBE INTO A SOCKET. Without necessitating the change of a single binding post, wire or batteries or headphones! The S-P-2 Adapter is a basic patent and is thoroughly covered.

Write for Big, New Catalogue No. 102A Price 20c

PITTSBURGH RADIO SUPPLY HOUSE

963 *Liberty Ave. Pittsburgh, Pa.* BELL TELEPHONE GRANT 3631

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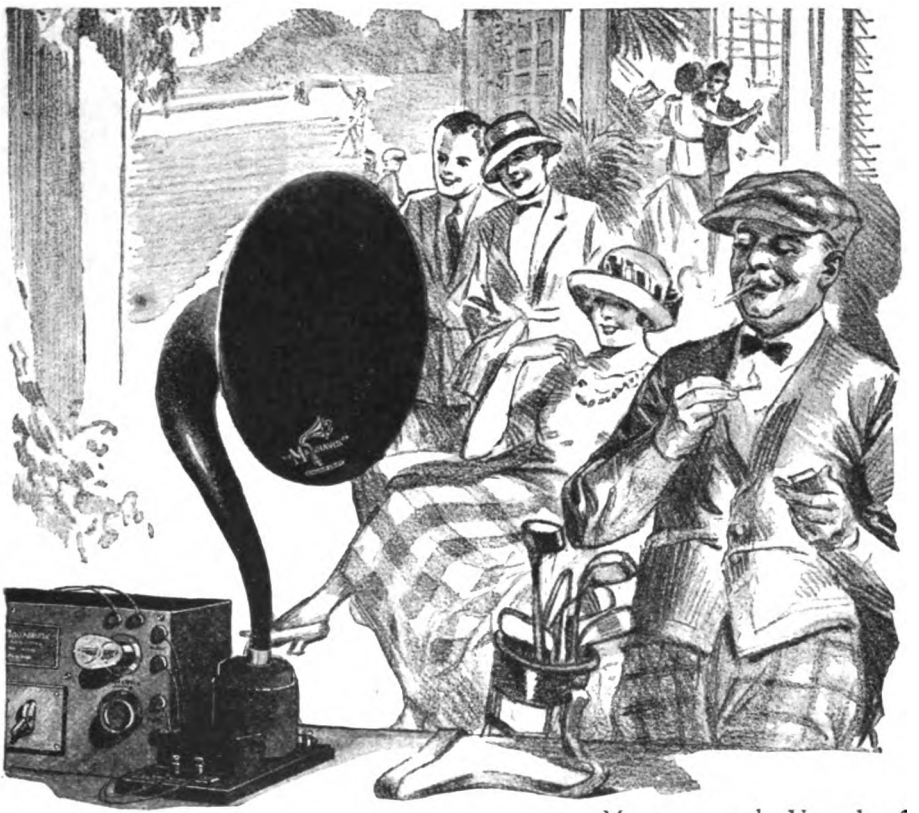

Magnavox on the Veranda of the Country Club

WHERE radio apparatus, like a professional entertainer, must meet the test of satisfying really discriminating people, a Magnavox Reproducer and Power Amplifier (as shown above) are certain to be installed.

Combination R-3 Reproducer and 2-stage Power Amplifier **$90.00.**

R-2 Magnavox Reproducer with 18-inch horn: the utmost in amplifying power. **$60.00.**

R-3 Magnavox Reproducer with 14-inch horn - - - - - - **$35.00.**

Model C Magnavox Power Amplifier
AC-2-C 2-stage - - **$55.00.**
AC-3-C 3-stage - - **75.00.**

Magnavox Products can be had of good dealers everywhere. Write for booklet.

The Magnavox Co., Oakland, California
New York Office: 370 Seventh Avenue

MAGNAVOX PRODUCTS

No Radio Receiving Set is complete without them

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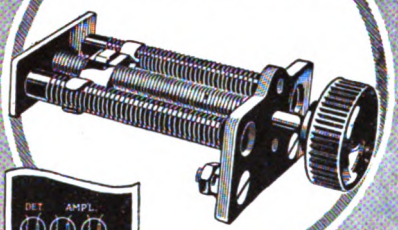
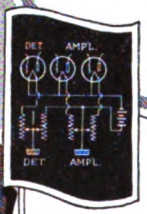
The Autostat
A Super Radio Rheostat





Can be used with 6-volt or WD 11 detector tubes, two amplifying bulbs or one 5-Watt power tube.

The difference between a jumbled mass of signals coming from everywhere and the "sharply-tuned" concerts received clearly and distinctly from far-away stations depends largely upon the careful adjustment of your detector filament current.

Heretofore, sharp tuning has only been partially obtained thru skillful "hair-breadth" manipulations of the filament rheostat. But with

The Autostat
A Super Radio Rheostat

these much-sought-for results can be secured by anyone. Just "twirl the knob"—a full turn produces a finer adjustment than a "hair's-breadth" turn on any other.

Economical — neat — small — compact. No carbon to break or change resistance. Unqualifiedly guaranteed. Popularly priced—**$1.35.**

If the ***Best*** *is none too good for the set you are building or have bought, see the Autostat at any good radio or electrical dealer* ***Today.*** *Or write direct for Free Bulletin which shows why the Autostat is radio's* ***Best*** *rheostat.*

DEALERS — JOBBERS
Write or wire for Radio's most attractive merchandising proposition.

THE AUTOMATIC
ELECTRICAL DEVICES CO.
132 WEST THIRD ST.
CINCINNATI, OHIO

Builders of Precision Rheostats since 1914

CHARGE YOUR RADIO BATTERY *at* HOME *for a* NICKEL

PATENTED ARMATURE
The HOMCHARGER'S only moving and wearing part, replaceable after thousands of hours' use for $1.00. Tungsten contacts now used exclusively. Will not stick, corrode or wear excessively.

Enjoyable concerts and maximum receiving range are obtained only when your battery is fully charged.

THE HOMCHARGER

charges your "A" or "B" battery OVER NIGHT for a nickel without removing it from your living room. Operates silently — charging rate governed automatically. No muss—no trouble—no dirt—requires no watching.

The HOMCHARGER is the ONLY battery charger combining all of these necessary features. SELF-POLARIZING —FIVE to EIGHT-AMPERE charging rate—UNDERWRITERS' APPROVAL—beautifully finished in mahogany and old gold—UNQUALIFIEDLY GUARANTEED. Over 100,000 now in use.

The minute you buy a radio set you need a Homcharger—get it then. All good radio and electrical dealers sell it complete with ammeter, etc., for $18.50. $25.00 in Canada.

Write for FREE circular showing why the HOMCHARGER is the BEST battery charger at any price.

MOTORISTS — THE HOMCHARGER will also charge your AUTO Battery.

THE AUTOMATIC
ELECTRICAL DEVICES CO.
132 WEST THIRD ST.
CINCINNATI, OHIO

Largest Manufacturers of Vibrating Rectifiers in the World

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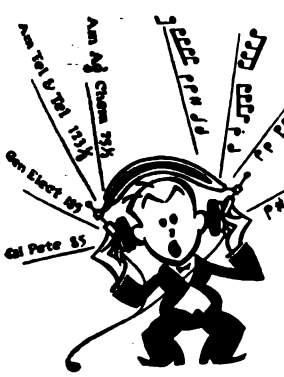


Soprano Solos *by* The Stock Exchange

When you try to tune in with a single circuit receiver, it is not surprising that songs should suddenly turn into market quotations and bedtime stories into weather reports.

For with several hundred powerful broadcasting stations all operating on one narrow wave band, it takes real selectivity and sensitivity to get a satisfactory radio programme.

Get a Paragon three-circuit receiver. Then you will have the pleasure and satisfaction of obtaining the station you want when you want it. Clear, complete programmes without interruption or disturbance.

Ask some experienced amateur what he knows about

PARAGON

Reg. U. S. Pat. Off.

RADIO PRODUCTS

The amateur will tell you that the Paragon three-circuit receiver, because of its great superior selectivity and sensitivity, can pick and choose between broadcasting stations of about the same signal strength with less than one per cent differential.

This means that with a Paragon receiver you get what you want when you want it—complete messages and clear music from the station you tune in on, without interruption and jamming. Until you have listened in with a Paragon three-circuit receiver, you cannot guess the real pleasure and fascination of radio.

Long before broadcasting popularized radio with the general public, Paragon equipment was the choice of the experienced amateur. He will tell you today that if you want quality and satisfaction, Paragon Radio Products are the best and safest buy on the market.

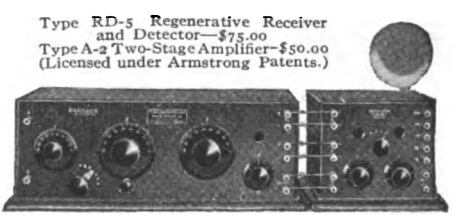
An illustrated Catalog of Paragon Radio Products Is Yours For the Asking

DEALERS—The Adams-Morgan Company has an interesting proposition to make to reputable radio dealers who believe in quality merchandise. Details on request.

ADAMS-MORGAN COMPANY
20 Alvin Ave., Upper Montclair, N. J.

Also Manufacturers of PARAGON	
Radio Telephone Transmitters	Amplifier Transformers
V. T. Control Units	Control Dials
Rheostats	Amplifiers
Potentiometers	Receivers
V. T. Sockets	Switches
Detectors	Variometers

Type RD-5 Regenerative Receiver and Detector—$75.00
Type A-2 Two-Stage Amplifier—$50.00
(Licensed under Armstrong Patents.)



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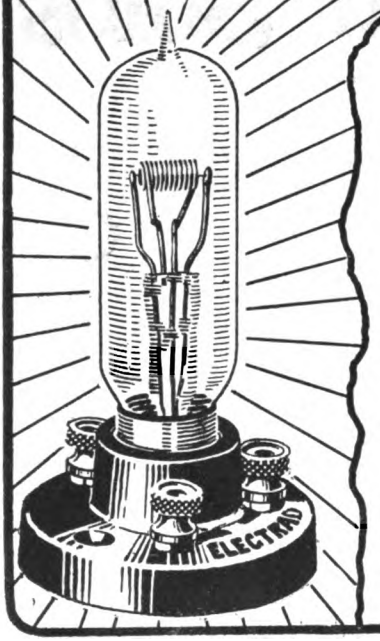

DRY CELL TUBE $2.00!

ELECTRAD DIODE

RADIO SENSATION OF 1923

The Electrad Diode has proven to be the biggest little thing in radio. Operating from two dry cells and requiring but a very small fraction of an ampere with no "B" Battery, it has taken its place as the most economical device of its kind in the world. The Diode has no grid, therefore it can produce no howling. As a two-element tube, it stands unmatched in sensitivity, quiet operation and long, serviceable life.

The Diode is NOT a substitute for a crystal. Rather, it is a new device, so inexpensive, so reliable and so perfect in operation that its use in place of a crystal is a matter of common sense. In clarity of tone and sweetness of reproduction, it is the crystal's only rival, yet it is far more sensitive, enabling its user to bring in stations that lie safely beyond the range of crystal receivers.

The Cost of the Diode is small, the results surprising. NO RADIO FAN CAN AFFORD TO OPERATE A CRYSTAL SET WITH THE DIODE AVAILABLE. Can be used with amplifiers. SOCKET FOR DIODE, 50c.

Sold by All Reliable Dealers. Manufactured Only by

The Electrad Corp. of America
428-30 Broadway, New York.

WHY METRO HEADPHONES ARE SUPERIOR

TRADE MARK METRO

ACTUATING COIL CORES

Metro Headphones faithfully reproduce every sound variation so that reception is always clear and natural. The magnetic current which operates the diaphragm is transmitted by the actuating coils through the soft Armco Iron Cores, which allow a ready change of magnetic strength.

It is this remarkable ability of the actuating coil cores to react faithfully to every magnet impulse that helps to produce Metro sensitivity. A small detail but perfection is made up of such details. Insist upon **Metro Headphones** because you can be sure that every detail is as it should be.

$6.00

Little Giant Receiving Set — A surprisingly compact set. Simplest, tuning device. Complete with Metro Headphones **$14.00**

Metro Wave Selector — Makes any set highly selective. Completely separates 360 from 400 meters..... **$7.50**

METRO ELECTRICAL CO., Inc.
Manufacturers of Metropolitan Radio Products
69 Goble Street — Newark, New Jersey

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Exide
BATTERIES

Uniform current cuts out the noise

EVERY radio amateur knows how disastrous battery noises are to clear receiving. You can avoid this annoying interference by getting the battery that insures a steady flow of filament current. That battery is the Exide Radio Battery.

This specially designed radio battery does its work uncomplainingly, and never requires much attention. The rasping, snarling noises often caused by fluctuating current in ordinary batteries do not exist in the Exide Battery. It delivers uniform filament current for every type of vacuum tube. You can count on the Exide for dependable, long-lasting service.

Exide Batteries are used in a majority of the government and commercial wireless stations and in every industry where a battery's response to the call of duty must not fail.

Any dealer in radio equipment will sell you an Exide Radio Battery, or you can get one at the nearest Exide Service Station.

THE ELECTRIC STORAGE BATTERY CO.
Philadelphia, Pa.

Service Stations Everywhere

Branches in Seventeen Cities

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BURGESS
RADIO BATTERIES

Are the accepted standard for radio circuits. Leading manufacturers recommend Burgess Batteries and they are specified by radio engineers. Being designed and built by radio engineers brings a guarantee of satisfactory service to you.

BURGESS "B" BATTERIES

Burgess "B" Batteries can be furnished in several types or styles and in varying capacities. Drop in to your dealer's store today. Select the Burgess "B" best fitted to the requirements of your set and invest confidently, knowing that in the judgment of thousands of users the Burgess is the one best radio battery.

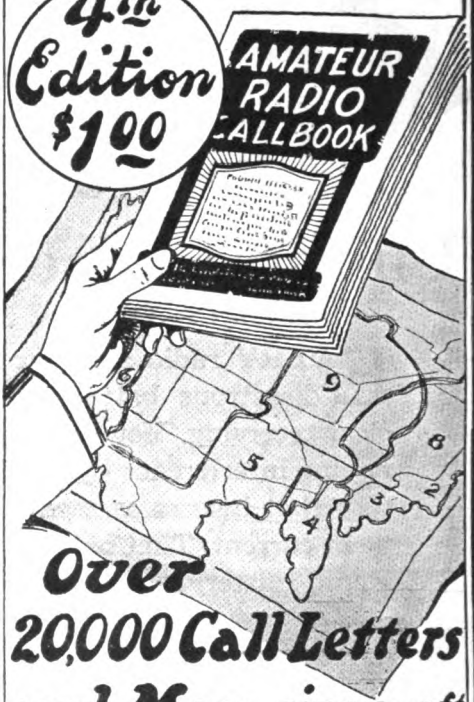
BURGESS No. 6 BATTERIES

Are recommended and have proven highly satisfactory for use in "A" or filament circuits where the 1½ volt vacuum tubes are used.

BURGESS BATTERY COMPANY
Engineers Manufacturers
Dry Batteries
Flashlight Radio Ignition Telephone
General Sales Office:
Harris Trust Bldg., Chicago
Laboratories and Works:
Madison, Wisconsin
Branches:
New York Boston Washington St. Paul
Kansas City New Orleans
In Canada: BURGESS BATTERIES, Ltd.
Winnipeg Toronto Montreal

BURGESS
RADIO BATTERIES
"ASK ANY RADIO ENGINEER"

Just Out



Over 20,000 Call Letters and Map-size 2x3 ft

Indispensable to every radio owner. Contains up-to-date list of over 20,000 Amateur, Commercial, Army, Navy, Transoceanic High Powered, and Broadcasting Stations in the United States and Canada; International Morse Code and Convention Signals; the construction and operation of the Reinartz Tuner, Detector, and one-stage Amplifier; also an abundance of other useful information.

Included with the book is a splendid two-color map of the United States and Canada, 2x3 ft., showing radio district boundaries, standard time lines, geographical location of broadcasting stations, etc.

Buy the Book with the Blue Cover

The greatest dollar value on the radio market. At your dealers or direct by mail. Use check or money order. Do not send stamps.

Dealers: write for proposition

Radio Directory and Publishing Co.
45-J Vesey Street New York City

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The Receiver of Tomorrow

The Symphony

Tomorrow in Radio means a wider and more useful as well as more entertaining broadcasting. Therefore, to the purchasers of receiving sets, the design, the material, the workmanship, the circuit and the assembly, all play an important part in the quality of reception, and distance heard.

The placing of a Symphony in your home is a permanent investment that will win your instant approval, and occupy a prominent place among your most cherished possessions.

The clear reception and unusual volume are the results of the high grade units, the fine workmanship, the most efficient circuit, and the correct assembly. The improved circuit used in the Symphony combined with the accuracy of its construction, has increased the selectivity to a marked degree.

The range of the Symphony Receiver is unlimited. Recently, in Chicago, Havana, Cuba, was tuned in not only on a head set but heard plainly on a loud speaker.

The Symphony Receivers are made in two types—Three and Two stages of audio frequency amplification.

If your dealer cannot furnish information on the Symphony, write for illustrated catalog, giving us his name.

JONES RADIO COMPANY

Lytton Building, Chicago

The Symphony is manufactured under the U. S. Patent No. 1113149, Armstrong Regenerative Circuit

All parts used in the Symphony are built and guaranteed by the Kellogg Switchboard & Supply Company for twenty-five years manufacturers of complete telephone equipment

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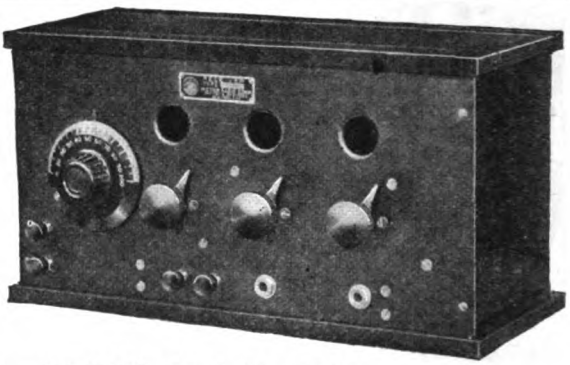
"Victor Senior"



A New Tuner, Detector and Two-Stage Amplifier

The ideal set for your vacation—compact, easy to move.

A very simple set to operate as there is only one master dial on which all tuning is done.

Distance is one of its many outstanding features.

LIBERAL DISCOUNTS TO JOBBERS and DEALERS

Catalog issued on request

VICTOR RADIO CORPORATION

795-799 East 135th Street New York City

The Most Wonderful Radio Loud Speaker in the World

$28.50

MAHOGANY FINISH

PHANTOM VIEW SHOWING

The Adjustable Air Gap

consists of an adjusting dial mounted in front of the cabinet, by means of which the distance between the magnetic poles and the diaphragm may be increased or decreased, thus varying the pull of the magnet on the diaphragm and permitting tuning up in complete harmony under all varying conditions of reception.

The DICTOGRAND

with the Adjustable Air Gap

Overcomes the defects common to all other radio loud speakers—the harsh jarring sounds, the noises and overtones.

Designed to operate on any vacuum tube receiving set, giving maximum results when two stages of amplification or more are used. Requires no extra batteries. You simply plug in—and listen.

The DICTOGRAND RADIO LOUD SPEAKER, like all Dictograph products, is guaranteed for a period of one year against all electrical or mechanical defects.

ASK YOUR DEALER TO DEMONSTRATE IT

The unusual demand upon our facilities has not enabled us to complete our distribution. If your dealer has not yet received his stock of **DICTOGRAND Radio Loud Speakers**, send to us direct.

Makers of the Famous Dictograph Radio Head Sets

DICTOGRAPH PRODUCTS CORPORATION

Dept. P. R., 220 West 42nd Street, New York City

Branches in All Principal Cities

Dealers: Order through your jobber; or send to us direct for names of authorized distributors.

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A Lamp Socket—Not a Storage Battery—Will Run Your Power Amplifier—

Use a General Radio Type 272 Power Amplifier with your loud speaker and do away with the storage battery

General Radio Company's type 272 Power Amplifier is a complete, self-contained unit and may be used with any type of receiving set—crystal or tube. No storage battery is needed if the detector is either a WD-11 tube or a crystal.

Simply screw the plug in a lamp socket on any 110 Volt A. C. lighting circuit. An On and Off switch, mounted at the side of the handsome metal case, permits a permanent connection being made with any convenient outlet, if desired. Two stages of amplification are provided, each stage using a five watt tube.

When a General Radio type 272 Power Amplifier is received from the dealer, all that is necessary is to slip one—or two—45 Volt plate batteries and one 4 Volt grid biasing battery into the compartment provided within the cabinet. Then turn on the tube, adjust the filament rheostat and grid biasing battery, close the hinged cover of the cabinet and for six months enjoy the most complete and satisfactory amplification you have ever known.

Price, exclusive of vacuum tubes and batteries—$40.00

Ask for a copy of Bulletin 912U

GENERAL RADIO COMPANY

MANUFACTURERS OF

RADIO AND ELECTRICAL LABORATORY APPARATUS

MASSACHUSETTS AVENUE AND WINDSOR STREET

CAMBRIDGE 39 **MASSACHUSETTS**

Standardize on General Radio Equipment Throughout

5164

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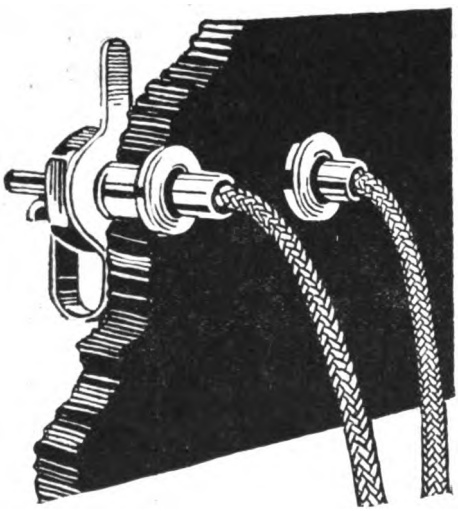
Read Why You Should Use

UNION RADIO PHONE TIP JACKS

(Pat. Applied For)

25c A PAIR



Here's the Radio device that you have been waiting for. These Phone Tip Jacks assure quick connection and a positive contact. They replace unsatisfactory binding posts. Soldering lug incorporated but use optional.

Accommodate any standard round phone tip and several sizes of bare wire. Great for W D 11 connections and coil mountings. Save buying expensive telephone plugs and jacks. They live up to the Union Radio Standard of Quality. Guaranteed to satisfy. Only 25c a pair.

FOR ASSURED RESULTS

you should "try out" Union Radio Tip Jacks, Variable Condensers, Rheostats, Vacuum Tube Sockets, Condensite Dials.

Union Radio Apparatus and Accessories are sold by most good dealers. If you can't obtain them from your local store mail your order to us. Write for a copy of our Catalogue A Radio Apparatus.

Wholesalers and Retailers:

Write for our liberal proposition. Dealers' Catalogue A and Price List, also samples, sent on request.

UNION RADIO CORPORATION
200 MT. PLEASANT AVENUE, NEWARK, N.J.
NEW YORK OFFICE — 116 WEST 32ND STREET.

Now Radio Fans Can Get More For Their Money

THE NEW "A" BATTERY

RADIO ACE BATTERY

For operating WD-11 Tubes using 1½ volts

There Is No Other Battery Like This Because:

It has a voltage of 1.60 per cell which is .10 higher than the ordinary dry cell and, inasmuch as the W D-11 tubes cannot be operated after the dry battery has dropped in voltage to 1.1, the ACE gives much longer service.

It has a specially constructed air pocket under the sealing compound to permit escaping gases to expand, thus preventing blown seals.

It is equipped with locknut terminals to assure absolutely leak-proof connections. Conductivity of current complete.

It sells for less.

Types	*Cells*	*Volts**
No. 61	1 cell	1½ volts
No. 62	2 cells	1½ volts
No. 63	3 cells	1½ volts
No. 64	4 cells	1½ volts

**Note: Because it is common to refer to dry battery voltage in terms of 1½ volts, each type is specified in these units, despite the extra voltage available.*

The Cells are of Special Radio Construction and Give Many Times the Combined Life Service of Single Cells, Used Individually one after the Other.

DEALERS: Here is a dry battery proposition that offers you more turnover and greater profit. Write at once. Dept. S.

THE CARBON PRODUCTS CO.
Lancaster, Ohio

Here is another remarkable battery for general ignition and camp lighting: "The Reliable Ace in a Metal Case."

THE NEW HOT SPARK IGNITION BATTERY

Metal case—non-short circuitable—4 cells 6 volts—long life.

DEALERS: Many of your radio customers are ignition customers.

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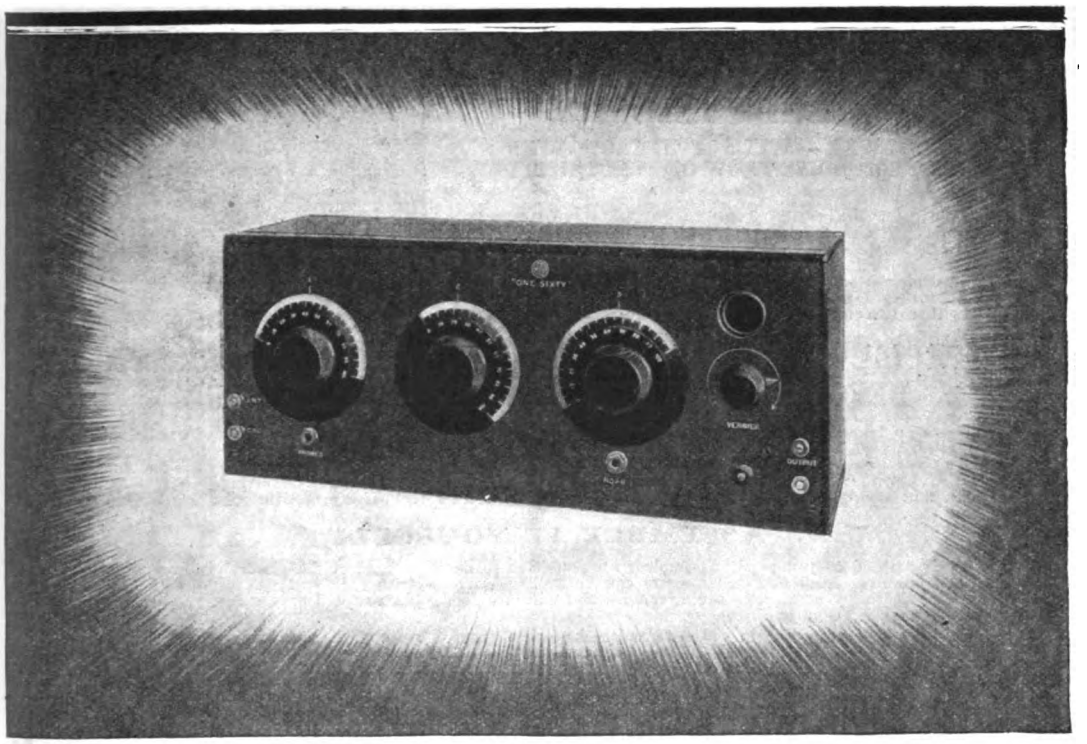

The famous FADA "ONE SIXTY" *with the* NEUTRODYNE *circuit—*

Neutrodyne

is the name given to a marvelous new radio receiver circuit invented by Professor L. A. Hazeltine, of Stevens Institute of Technology, Hoboken, N. J., and used in the FADA "ONE-SIXTY" receiver.

Only four vacuum tubes are used. The selectivity is remarkable and yet the dials can be easily adjusted to receive distant stations.

The FADA "ONE-SIXTY" will receive broadcasted concerts from the Atlantic to the Pacific and with loud speaker intensity.

Denver, Colo., San Antonio, Tex., Havana, Cuba, and Los Angeles, Calif., are some of the far distant stations listened to from New York City, using only a small indoor antenna.

The FADA "ONE-SIXTY" is the ideal receiver—the cost $120.00

F. A. D. ANDREA, INC., 1581-D JEROME AVE., N. Y. CITY

The FADA "ONE SIXTY"

—WITH THE NEUTRODYNE CIRCUIT—

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A "B" Battery Built for Radio By Radio Experts

HIGH POWER — WITH A STEADY EVEN FREE FROM NOISE FLOW OF ELECTRICITY

Not a cricking sound—just a pure tone of the radio message. The SIDBENEL STORAGE "B" BATTERY, different than others, is made in a one-piece hard-rubber container. The ten necessary cells are molded into it—making the battery most sound and rigid. The complete battery measures only two and one-half inches wide, three inches high, four and seven-eighths inches long, and weighs less than three pounds—yet it has as much power as batteries three times the size and price.

SPECIAL PATENTED PLATES CHARGED AND FORMED BEFORE LEAVING THE FACTORY ARE USED

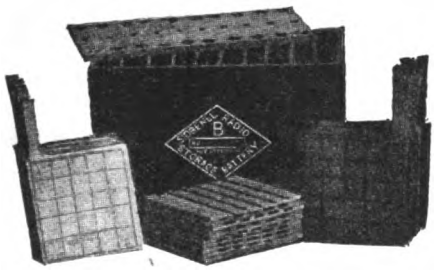
They will give an immediate discharge of FIFTEEN AMPERE and a voltage of twenty-two and one-half variable from two volts up. A single charge will give approximately six months' service; however, should it become partly discharged at any time, just connect it to your charger, lamp-socket or lighting generator, and within a few hours your SIDBENEL STORAGE "B" BATTERY will be recharged to its full capacity, costing you less than one-half a cent, and saving you the price of a new battery. Each time the battery becomes discharged you simply recharge it.

ASSEMBLE IT YOURSELF

The battery is shipped to you partly assembled; all you have to do is to connect the plates together, which takes less than ten minutes. Any boy of ten years can do it. Instructions with each battery. Connect to any lamp-socket or farm-lighting generator, as per directions, and within a few hours you will have a battery that is superior to any on the market. Give it a trial.

One single unit—23 volts—variable from 2 volts up.....$4.25

Two single units.....$8.10	**Four single units.....15.25**	**Six single units.....$22.25**
Three " " 11.75	**Five " " 18.50**	**Seven " " 25.75**



ASSEMBLED PER UNIT $4.65

Send for Free Catalog

Sidbenel

RADIO EQUIPMENT MFG. CO.
Dept. P. R.
25 Mt. Eden Ave. New York City

"REGAL" INDUCTANCE SWITCH

Complete with Knob and Dial
$2.00

Two Biggest Hits In Radio

Regal Inductance Switch

Does away with all drilling of holes in panel. Does away with all switch points. Requires but one hole to attach to panel. Complete 15 point switch in one unit.

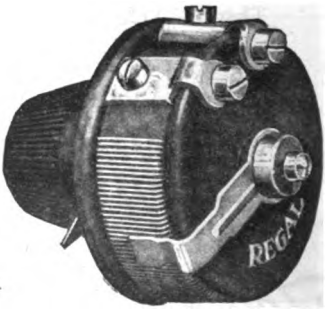
Regal Rheostat

A scientific precision instrument. Full exposed resistance wire. More sensitive than a vernier. 6 Ohms resistance —2.2 Amperes.

Condensers, Power Rheostats, Potentiometers, Vario-Couplers, Jacks, Knobs, Dials, etc. Send for our new catalog No. 27.

(If your dealer does not carry Regal Radio Products write us direct)

"REGAL" RHEOSTAT



Complete with new Regal Knob
$1.00

THE AMERICAN SPECIALTY COMPANY **BRIDGEPORT, CONN.**

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The PACENT 50c.
New UNIVERSAL PLUG
Number Forty

The quality of this plug and its low price enable you to enjoy satisfactory plug connections on every piece of your radio equipment. Look for the PACENT Trade Mark and ask for PACENT New Universal Plug No. 40.

Materials that last
Simple, Sturdy Construction
Permanent Biting Contact
Perfect Insulation

The makers of the FIRST Radio Plug now offer the first Quality plug at a popular price. This plug meets perfectly every radio requirement.

Don't Improvise—"Pacentize"
Write for Descriptive Bulletin P-5

PACENT ELECTRIC COMPANY, Inc.

Executive Offices
22 Park Place
New York, N. Y.

PACENT

Sales Offices
Chicago Washington, D. C.
Philadelphia Minneapolis
St. Louis San Francisco

Members Radio Section, Associated Mfrs. of Electrical Supplies
Canadian and British Licensees: Colonial Radio, Ltd., Hamilton, Can.

Pacent
RADIO ESSENTIALS

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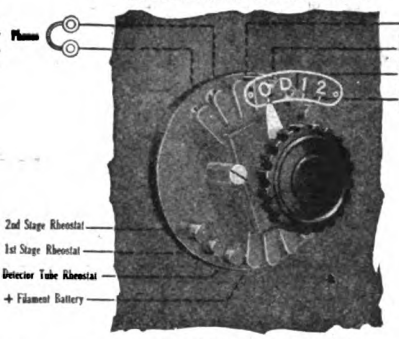
FIL-FONE
CONTROL SWITCH

A-C DAYTON



A-C DAYTON

Dispenses with
Jacks
Plugs

Saves
Wire
Time
Money

Protected by Patents Pending
PRICE $3.00

The **Fil-Fone Switch** is the latest addition to our remarkably complete line of Radio Products. Designed for convenience and elimination of surplus parts. Gives the operator perfect control of his tubes without noise or inconvenience of plugging in phones from one stage to another.

The **Fil-Fone Switch** automatically lights the filaments and connects the "B" Battery and telephones to either Detector, first stage of amplification or second stage of amplification as desired, with a positive and progressive operation. It has an "OFF" position which disconnects the filament battery, "B" battery and phones from the set.

This method of filament control is sure to be universally adopted in set building because of its simplicity, convenience and saving of expense. Sold ready for mounting, with complete wiring diagram.

Send for Free Descriptive Circular, F. F. S. No. 1
(Complete catalog of Radio Parts with useful Radio information sent on receipt of six cents in stamps for mailing.)

The A-C Electrical Manufacturing Co. - Dayton, Ohio
Makers of Electrical Devices for Over 20 Years

A SUMMER NECESSITY

TIMMONS TALKER

DURING sultry summer nights no one will want to listen in with a pair of hot, restraining and cumbersome earphones pressing against their head.

BY attaching a TIMMONS TALKER to your set you can let everyone of your party "Enjoy Radio the Unselfish Way."

THE TIMMONS TALKER

has adjustable amplification so you can always secure just the right tone value for any audience listening to your set. It is self-contained in a handsome mahogany cabinet. Needs no extra batteries.

WE urge you to buy your TIMMONS TALKER before the summer demand begins. Sold by all worth-while dealers.

J. S. TIMMONS

337 East Tulpehocken Street, Philadelphia, Pa.

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MU-RAD RECEIVERS SUPREME

LIKE THE POWERFUL TELESCOPE that makes us neighbors to the stars, MU-RAD Receivers annihilate distance with delightful ease. Honolulu is as near to St. Louis by MU-RAD reception as New York.

So marvelously sensitive that it requires only a 2-foot loop aerial. Distinct reproduction with hair breadth selectivity, and yet easy for even a novice to operate. Conservatively guaranteed for 1000 miles.

Write for literature

The New Star in the Radio World

MU-RAD LABORATORIES, INC.

809 FIFTH AVE. ASBURY PARK, NEW JERSEY

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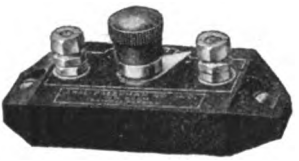
FRESHMAN PRODUCTS — ACCURATE AND DEPENDABLE

VARIABLE RESISTANCE LEAK



With .00025 mfd. MICON Condenser Combined **$1** Without Condenser **75c**

Unbroken range—Zero to 5 Megohms—Clarifies signals, lowers filament current, increases battery life, eliminates hissing.

"MICON" Tested Mica CONDENSERS

Size	Price
.00025	$0.35
.0005	.35
.001	.40
.002	.40
.0025	.50
.005	.75
.006	1.00
.01	1.50

Assure absolute noiselessness—clarity of tone—accuracy—constant fixed capacity.

Freshman products are standard and can be used successfully with practically any circuit.

ANTENELLA

No antenna or aerial needed. Eliminates all the inconveniences in radio, operates from any light socket. Price only $2.00.

At your dealer's—otherwise send purchase price and you will be supplied postpaid.

$2

CHAS. FRESHMAN CO., Inc.
106 SEVENTH AVENUE NEW YORK

Just Consider

—the essential features necessary to make an audio frequency transformer a good one—

1. *High Amplification.*
2. *Minimum Distortion.*
3. *Low Interstage Linkage.*
4. *Convenient Mounting.*
5. *Compactness.*

Cotoco transformers make these ideal features facts. And the finish will surely please you.

"Built First to Last"
$5.00
At Your Dealer's

COTO-COIL CO. PROVIDENCE

Pacific Coast Branch, 329 Union League Bldg., Los Angeles

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Rich Resonance that Only WOOD Can Give

THEY call MUSIC MASTER the "Stradivarius Among Amplifiers." For its horn is WOOD, with that pure, mellow-sweet tonal quality of the human voice that wood alone can simulate. (Phonograph experts proved the principle before radio.)

A powerful amplifying unit in the art-metal base of MUSIC MASTER sends sounds up through a cast-aluminum "gooseneck"—cast aluminum, so it won't vibrate. This conveys true tones to the wooden horn, where they are beautifully enriched, humanized and given to the audience as they are actually sung, played or spoken.

There is only one MUSIC MASTER. Get it and you won't regret it! Hundreds of orders are pouring in daily. Demand actually exceeds supply, so get your order in NOW! Comes complete, ready to attach in place of head 'phones. No extras to buy. Hear MUSIC MASTER at your dealer's today. COMPARE it with any other amplifier, regardless of price! Literature on request.

14-inch Amplifier complete, $30

21-inch Amplifier complete, $35

Ask about the GERACO Phonograph Attachment which makes an efficient radio loud-speaker of your Victrola or Columbia. Only $10.

GENERAL RADIO CORPORATION

Makers and Distributors of High-Grade Radio Apparatus

CHICAGO — PHILADELPHIA *624-628 Market St.* — PITTSBURGH

JOBBERS—DEALERS

A MUSIC MASTER will be sent to you with full privilege of return.

GERACO
PROVEN RADIO PRODUCTS

Write for full description of the GERACO line, and prices.

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Built on Honor

The Acid Test

Gently tap one terminal of Ambassador Phones on a cent, or your tongue, and a faint "click" will be heard.

(Other phones will not stand this test.)

Type A B	Prices
2000 Ohms	$5.00
3000 Ohms	5.50
4000 Ohms	7.00
5000 Ohms	8.00

Individuals may order by mail and we will gladly ship C. O. D.

$1000 REWARD

to anyone showing proof of our refusing to stand back of our guarantee on Ambassador Phones.

Specifications

Adjustable (navy type) headbands, comfortable and strong, beautifully nickeled.

Case of heavy stamped aluminum.

Cap of finest hard rubber and unbreakable.

Coils wound with highest grade enameled copper wire.

Magnets of Chrome steel will retain their power for years. 5 foot cords—best grade tinsel.

Weight, 12 ounces. Shipping Weight, 1 lb.

Our Guarantee

If you are in any way dissatisfied with our product, return same within thirty days and your money will be refunded on request

Special Discounts to Dealers

TOWER MANUFACTURING CO. - 114 Station St., Brookline, Mass.

"ALL AMERICAN"

Sets World Record for Long Distance Radiophone Receiving

When WDAP CHICAGO Talked to S. S. BERENGARIA

The Signals Were Amplified Aboard-Ship Thru "ALL-AMERICAN" AMPLIFYING TRANSFORMERS

WDAP, The Drake Hotel, Chicago, made history in radio, by talking day-by-day with the S. S. Berengaria, enroute New York to France. Miss Florence McDonald, a passenger, installed Standard Zenith Receiving Set in the steamship cabin, and, every evening during the voyage, WDAP talked to her and other passengers from Chicago, their voices coming clear and strong with the personality easily recognizable.

The set used by Miss McDonald is one of the regular Zenith Sets, manufactured by the Chicago Radio Laboratory, Chicago, Ill. It contained, as standard equipment.

"ALL-AMERICAN AMPLIFYING TRANSFORMERS

R-10—Radio Frequency (150-500 meters) $4.50 R-13—Audio Frequency (Ratio 10 to 1) $4.75
R-12—Audio Frequency (Ratio 3 to 1) 4.50 R-21—Audio Frequency (Ratio 5 to 1) 4.75

Send for our circular — "Caseading of Amplification". Also our Free Book of Radio Hookups.

AMERICAN **RAULAND MFG. CO.** AMERICAN

200 N. Jefferson St., Chicago, Ill.

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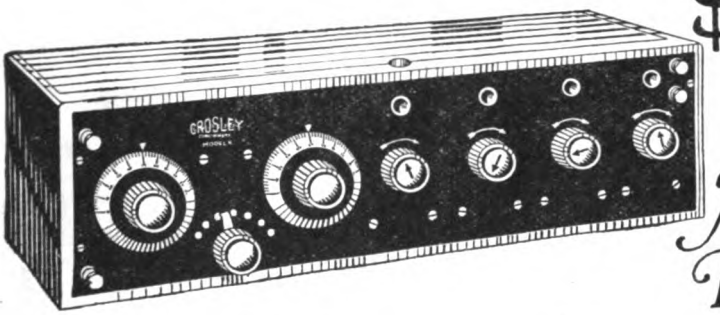
CROSLEY Model X

$55



A 4 tube Radio Frequency Set

THE HIT OF THE RADIO WORLD
FOR SALE by Good Dealers Everywhere
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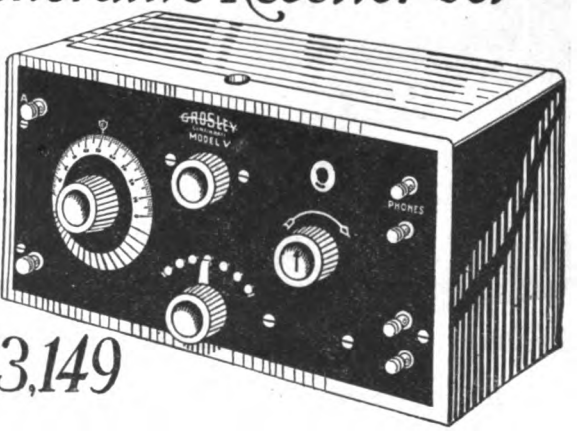
CROSLEY MANUFACTURING COMPANY
516 ALFRED STREET CINCINNATI, OHIO

CROSLEY Model Vc

$20 Regenerative Receiver Set



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The trade name "Crosley" is used by permission of the Crosley Manufacturing Company.
Write for FREE Catalog!

THE PRECISION EQUIPMENT CO.
Powel Crosley Jr. President
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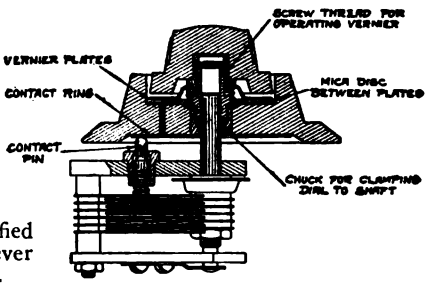
NEW "UNITED" VERNIER
A MIRACLE-WORKER



In Fine, Selective Tuning.
Operates on a New Principle.

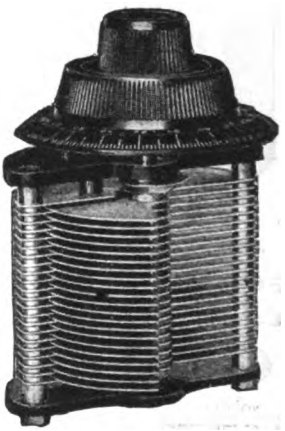
Will bring in the elusive stations that have thus far defied you, by giving at least *twice* as fine a tuning as has ever been possible with the best condensers thus far developed.

Can be attached to any plate condenser, by drilling one hole in top plate.

Price, each, postpaid, $2.50

"UNITED" VARIABLE CONDENSERS WITH NEW VERNIER

43-plate—each $6.50
23-plate—each $6.00
11-plate—each $5.50



"UNITED" TRANSFORMER

Audio Frequency. Amplifies detected signals so they come in clear and strong, for either headphone or loudspeaker reception.

Each $4.50

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SAN FRANCISCO OFFICE, 709 MISSION ST., SAN FRANCISO, CAL.

$45.00

CHELSEA REGENERATIVE RECEIVER

A Real Broadcast Receiver

Range 150 to 800 meters
¶ Perfection in design
¶ Pleasing appearance
¶ Simple and accurate tuning

A Chelsea product, embodying Chelsea equipment throughout.
Licensed under Armstrong U. S. Pat. No. 1113149. For amateur use only.

Write for our new No. 7 Catalogue

CHELSEA RADIO COMPANY

177 Spruce Street **Chelsea, Mass.**

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The Loud-Speaker With the Natural Tone

The Bristol "Audiophone" will bring into your presence the actual "tonal personality" of the speaker, the singer or the player. You will hear them as they are—not disguised by mechanical distortion. The "Audiophone" is a true sound reproducer, retaining all the fine gradations of tone quality, volume and feeling which distinguish the original performance of the artist. You forget the instrument, in your enjoyment of the entertainment it brings to all your household and the guests who may join you.

BRISTOL
TRADE MARK
AUDIOPHONE
Reg. U. S. Pat. Office
LOUD-SPEAKER

MOST SIMPLE AND EFFICIENT
Construction Covered by Basic Patents

Years of research in sound reproduction, in the laboratories of an established engineering concern, have made the "Audiophone" what it is—have given it its round, full tone, its ample carrying power, its distinctive freedom from blurring and distortion. It needs no separate storage battery for magnetizing current, and can be used with any two or three stage power amplifiers.

"AUDIOPHONE SR." Complete, 15-inch bell, $32.50
"AUDIOPHONE JR." Complete, 13-inch bell, $22.50

A new Bristol single stage power amplifier for use with the usual two stage amplifier can be furnished, which will greatly increase the range of the Audiophone where desirable. Price $25.00.

Ask your dealer to demonstrate the "Audiophone." If he hasn't it, write us—we will see that you are supplied.

THE BRISTOL COMPANY
WATERBURY **CONNECTICUT**

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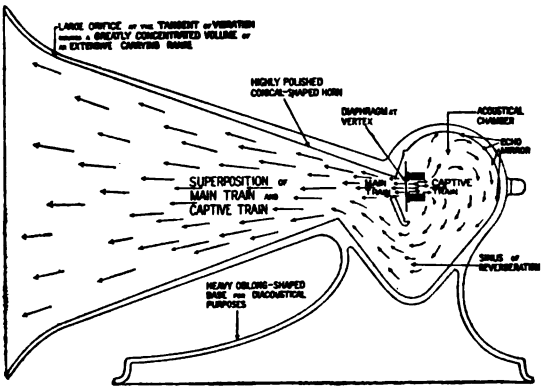


ECHO-TONE

GIVES FIBRE NEEDLE TONE TO THE RADIO PHONE

An acoustical chamber, an echo mirror and a sinus of reverberation, has made **Echo Tone** more than a ***horn,*** it is an acoustical instrument.

Convince Yourself of Its Faithful Service

If there is no Echo-Tone dealer near you, send a check or money order for $35.00 direct to us. Upon receipt of the money, we will immediately express an Echo-Tone to you. Try it out on your own set. If it does not prove entirely satisfactory to yourself and family, replace it in its wooden box and give it to the expressman consigned to us. Simply mail us the express receipt, not even necessary to write us your reasons for returning it. As soon as we receive the receipt, we will refund your money, without even waiting until we receive the instrument. Remember, we pay express charges both ways, making it just as convenient as though you were buying in the same city.

QUALIFIED DEALERS WANTED

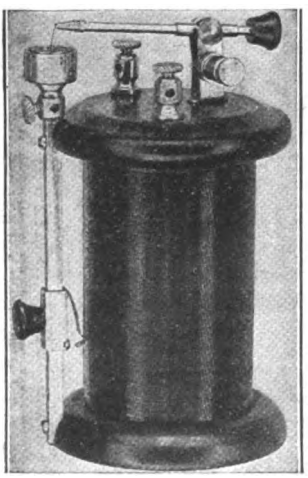
Introducing ECHO-TONE, thruout the country, we are sending a limited number to responsible dealers on a 10-day trial with the privilege of returning at our expense if it does not prove to be entirely satisfactory. Write at once if you wish to be the dealer to secure the demonstrating ECHO-TONE that has been allotted to your district.

Retail Price, $35.00

WILLIAMS RADIO COMPANY

Radio Tone Specialists

1438 Washington Blvd. **Detroit, Mich.**

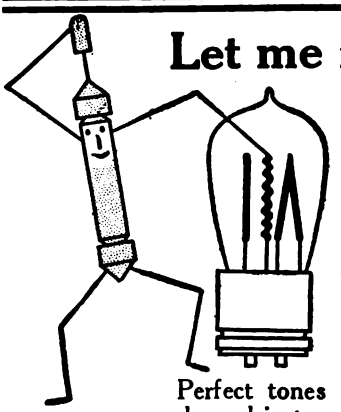


Crystal Set $2.50

The Ritter Grand Crystal Set will tune up to 600 meters and receive all concerts within 25 to 50 miles. It is made of the best materials, stands six inches high and has a 100% rating from the Technical Department of "Popular Radio."

Free circular on how to erect your aerial sent upon request. We invite jobbers' and dealers' inquiries.

RITTER RADIO CORPORATION
232 Canal Street
New York City



Let me *regulate* Your Grid Leakage

No. 201A—Special, the only leak made for this size tube, 2 to 10 megohms

No. 101—Up to 5 megohms

No. 100—Up to 100,000 ohms

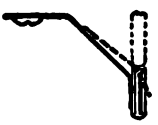
75c each

Perfect tones in the phones depend just as much on close grid leak regulation as on filament current control. That's why Mr. E. T. Flewelling recommends DURHAM Variables—the plunger permits exact regulation. Buy from your dealer.

Durham & Co., 1936 Market St., Philadelphia

DURHAM Variables High Resistance

Na-ald W.D. 11
No. 411



Na-ald De Luxe
No. 400

It's the contact that counts

The special phosphor bronze clips of the Na-ald W. D. 11 Socket maintain perfect contact regardless of any variation in tube prongs and bases.

Moulded from genuine Condensite, these sockets are made for use with the famous W. D. 11 tubes, operated by a single cell battery.

The Na-ald De Luxe V. T. Socket is of highest quality throughout. Its laminated phosphor bronze strips press firmly with a side wipe action on the contact pins, keeping surface clean and insuring perfect contact.

These sockets retail at 75c each

Send stamp for dial, small-space socket, condenser and R 4 transformer circulars

ALDEN MANUFACTURING CO.
Formerly Alden-Napier Co.
Dept. C **52 Willow Street**
Springfield, Mass.

NA-ALD

Booklet with wiring design instructions for Hazeltine's Neutrotyne and the Flewelling Super-regenerative Circuits, and a number of standard circuits, packed with each socket.

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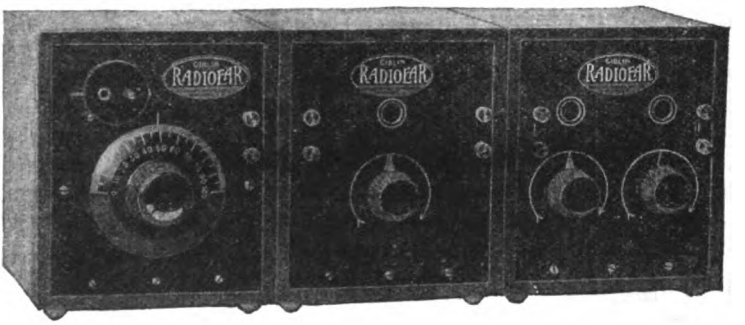
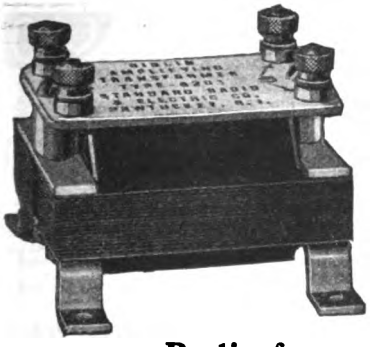
GIBLIN
RADIO APPARATUS

Every product manufactured by us is the result of the inventive genius of Thomas P. Giblin. For years this master inventor has concentrated on the development of wireless telegraphy and telephony. The three leaders illustrated here are perfect in design and construction, and their performance is guaranteed.

The "RADIOEAR" Vacuum Tube Receiving Set



This set includes the new Giblin receiver, detector and two-stage amplifier. The single-control tuner is easily and quickly tuned with full efficiency on any wave length. Local and distant stations can be heard with perfect clearness. The amplifier secures maximum volume without distortion. For the average radio enthusiast, this set will do all that could possibly be desired. Price, $50.00.



Audio-frequency Amplifying Transformer

This transformer has won the approval of radio enthusiasts from coast to coast. It is designed for use with standard amplifying tubes, and gives maximum amplification without noise or distortion. May be placed in any position without pre-magnetic coupling and squealing. Price mounted, $4.50; unmounted, $3.50.

Radio-frequency Amplifying Transformer

Features: Simplicity of operation; elimination of static and interference; loop reception of signals made possible regardless of the distance of transmitting station; maximum amplification; maximum resistance without the use of iron; maximum coupling between primary and secondary winding; minimum of distributed capacity. Price $7.00.

If your dealer cannot supply you, order direct.

STANDARD RADIO & ELECTRIC CO.
PAWTUCKET, RHODE ISLAND

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Announcing

THE NEW JENKINS VERNIER RHEOSTAT

CALLED THE UNITY VERNIER RHEOSTAT

An improvement on the Jenkins Rheostat, manufactured and sold by us heretofore.

The UNITY VERNIER RHEOSTAT has a BAKELITE base.

Genuine NICHROME RESISTANCE WIRE.

PATENTED adjustable screw fastens wire, thus eliminating all "loose wire" trouble.

PATENTED CUT OUT SWITCH with positive spring contact mounted directly in Rheostat, permits switching on or off with tuning unchanged.

PATENTED METHOD OF FASTENING resistance wire permits easy changing of wire to obtain a resistance suitable to any tube, or to replace if burnt out.

Suitable for use in the detector circuit of the four-circuit tuner.

Price: $1.75. Add ten cents for postage. ***Hear a set that uses one.***

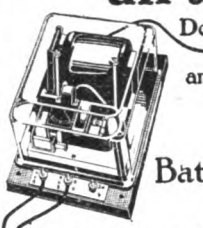
UNITY MANUFACTURING COMPANY, 224-232 N. HALSTED ST., CHICAGO
CONTRACT MANUFACTURERS

DEALERS AND JOBBERS WRITE FOR SAMPLES

WWJ | KDKA | WSB | KSD | WOC

WHAS | WGL | KYW | NAA | KFI | WMM | WAG | KHJ | WHB

Hear them all, all the time



Don't miss a program
Charge your **A** and **B** Batteries at home with a

Valley Battery Charger

Simple, safe, convenient. Cannot harm your batteries. Thousands of users would not be without it. At radio dealers—or write us.

Valley Electric Company

ST. LOUIS, MO.

WGY | CFCA | WBAP | KFKA | WEAF | WDAF | WHA | WJAY

WOI | WMC | WDAP | KDYX | PWX

Warren Radio Loop, cut away to show construction

Direction Finding

WARREN RADIO LOOP

A New Radio Pleasure

LOCATE ships at sea, trace amateur stations to their hiding places, direct your receiving in the full path of broadcasting stations.

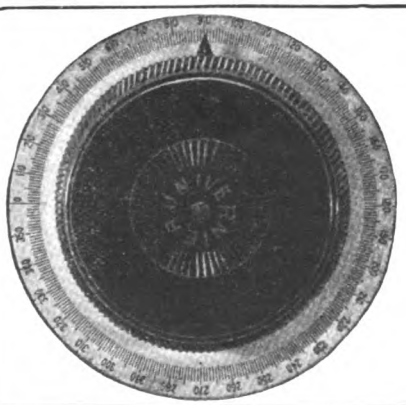
THE type B2537 or type BL2520 Warren Radio Loop, the most compact, efficient, attractive loop aerial, is all you need. Our new Bulletin I-102 explains the fascinating art of direction finding and gives hookups.

A Type for Every Set—at the Best Dealers

Type-A-727 (300-700 meters) 6 inches square—non-directional.....$10
Type-A-7236 (175-1000 meters) 6 inches square—non-directional...$12
Type-B-2537 (300-700 meters) 18 inches square—directional.....$20
Type-BL-2520 (200-18,000 meters) with honeycomb coil. 18 inches square—directional.....$25

Send for Bulletin I-102

V-DE-CO RADIO MFG. CO. Dept. FF. **Asbury Park, N. J.**



WHY NOT HEAR 'EM ALL?

The UNIVERNIER will make any instrument on your radio set "vernier" in its operation. Your outfit will be at least 100% more selective than before, and enable you to pick out with precision, stations that were entirely missed by usual adjustment.

By turning the UNIVERNIER as you would an ordinary knob, the speed of your instrument shaft is reduced nearly one-twelfth. By pressing toward the panel against light spring tension the UNIVERNIER will function as an ordinary knob. The UNIVERNIER takes the place of the common knob or dial, and is easily installed in a few minutes on ordinary variable condensers, variometers, tickler coils, variocouplers, potentiometers, and rheostats. It is the *logical* way to obtain genuine vernier adjustment.

Made in two sizes

No. 251 for ¼" shafts **No. 188 for 3/16" shafts**

The UNIVERNIER $1.00
Special silver plated 360 scale for use with the UNIVERNIER..... .25
Complete $1.25

At your dealers or postpaid on receipt of the above amount.

Discounts for jobbers and dealers.

WALBERT MANUFACTURING COMPANY, 933 Wrightwood Ave., Chicago, Ill.

P. S.—The UNIVERNIER will add to the appearance of any set.

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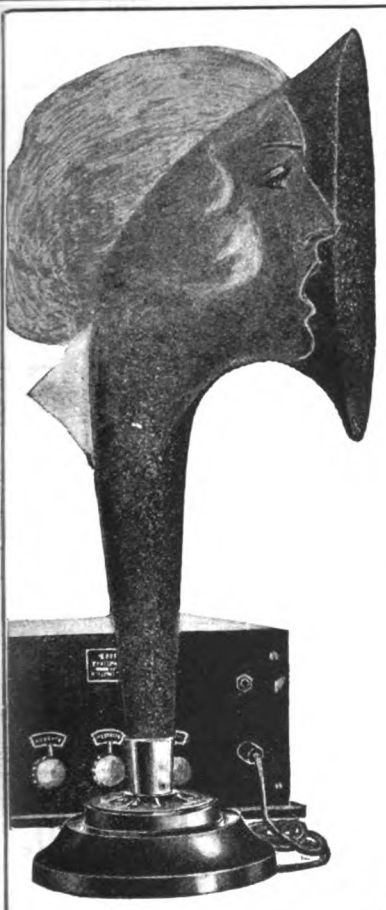


A Real Musical Instrument

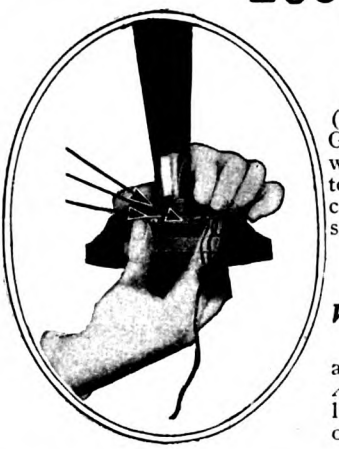
ACTUAL REPRODUCTION, of the artist's music, as broadcasted, is at last attained in the **Atlas Amplitone** Loud Speaker without blast or distortion. The artist's personality breathes again in the full, natural, vibrant tones of the Amplitone Re-PRODUCTION. Musical critics and radio fans, who have heard the Amplitone, agree that, at last, the musical superiority of even the finest phonographs has been surpassed. Embodies exclusive acoustic principles including the marvelous double diaphram.

Atlas AMPLITONE
LOUD SPEAKER

◆ ◆ ◆

NO loud speaker is perfect, unless it can be adjusted to your own individual set. The **Atlas Amplitone** is adjustable to any set. Complete with connecting cord

$25



Amplitone Unit

The **Atlas Amplitone** Unit (without base or horn), with Grafonola Attachment, for use with your own horn or base or to convert any phonograph (except the Brunswick) into a loud speaker. With attachment

$13.50

Write for Amplitone Booklet

Write for illustrated booklet and the name of your nearest *Amplitone* dealer. No other loud-speaker can take the place of the *Amplitone*.

Multiple Electric Products Co., Inc.
7 Orange Street **Newark, N. J.**

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Thrills!!!

TUSKA TRADE MARK RADIO

Thrills never end when you have a Tuska Popular—the regenerative receiving set that experts recommend. Signals clear and sharp come in night after night from faraway stations. And for nearby programs, plenty of volume without distortion. Every part Tuska-made; known for 12 years as fine radio instruments.

TUSKA POPULAR No. 225
Regenerative Receiving Set, Tuska receiver, detector and 2-stage amplifier, licensed under Armstrong U. S. Patent No. 1,113,149. Catalog No. 15-A, showing Popular and other sets, on request

TUSKA RADIO

Qualitone

RADIO HORNS

$4.50

No. 1 Holds two phones.
No. 1R Holds one phone.
Beautifully finished in dark red mahogany
Equipped with a patented

DOUBLE TONE CHAMBER

that produces sweet tones and clear articulation. Guaranteed to produce plenty of volume if used with a two stage set.
THOUSANDS OF DEALERS are selling Qualitones. Ask your dealer to order for you if he is not supplied.

THE DUAL TOOL COMPANY
12325 Superior Avenue **Cleveland, Ohio**

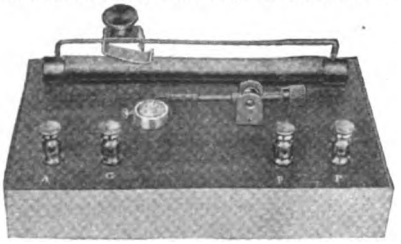
DEPENDADLE TESCO **LINE**

INSTRUMENT MAKERS SINCE 1909

PRECISION HIGH EFFICIENCY

CRYSTAL SETS

Guaranteed to receive local broadcasts with volume and clarity equal to any sets manufactured



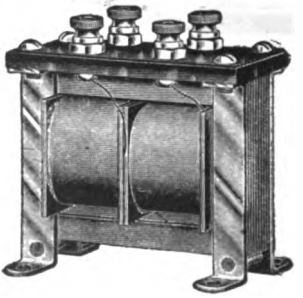
Without Phones or Aerial

TYPE "A" (Shown in out) . . $1.25
TYPE "B" De Luxe . . $6.00
Type A (complete), $6.00 Type B (complete), $11.00

Sent prepaid upon receipt of express or postal money orders.
Money refunded if not absolutely satisfactory.
Dealers and Jobbers write for discounts.

THE EASTERN SPECIALTY CO.
3552 N. Fifth Street, PHILADELPHIA, PA.

RITTENHOUSE TYPE W. D.



Audio Frequency Transformers are designed to be used in conjunction with **PEANUT TUBES.** Turns Ratio 3 to 1.

Price, $4.00

At your Dealer's, or postpaid upon receipt of price

THE A. E. RITTENHOUSE CO.
Honeoye Falls, N. Y.
Transformer Manufacturers for over 20 years

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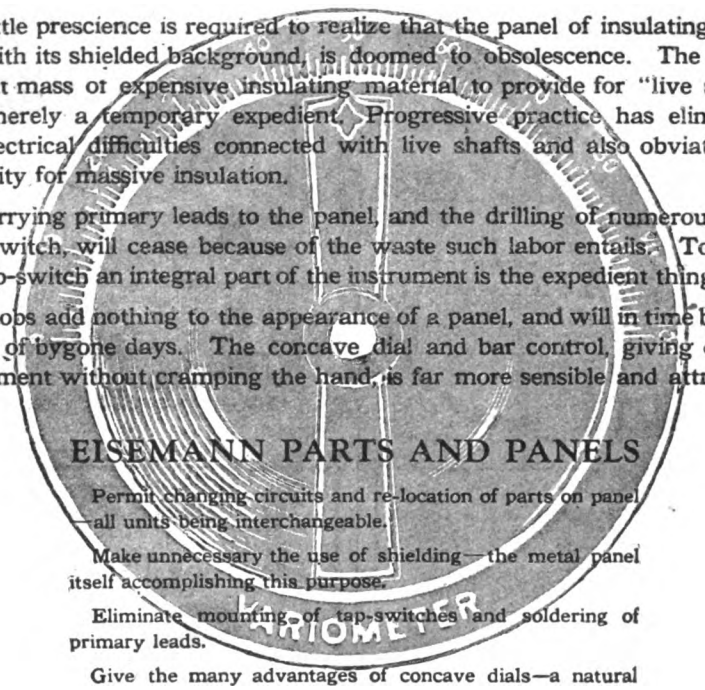
THE RADIO SET OF THE FUTURE

IT cannot be foretold what combination of units will be used, or the circuits that may be employed in the Receiver of tomorrow. It is obvious, however, that today's conventional set will soon be considered crude and antiquated.

Little prescience is required to realize that the panel of insulating material, with its shielded background, is doomed to obsolescence. The use of a great mass of expensive insulating material to provide for "live shafts" was merely a temporary expedient. Progressive practice has eliminated the electrical difficulties connected with live shafts and also obviated the necessity for massive insulation.

Carrying primary leads to the panel, and the drilling of numerous holes for a switch, will cease because of the waste such labor entails. To make the tap-switch an integral part of the instrument is the expedient thing to do.

Knobs add nothing to the appearance of a panel, and will in time become a relic of bygone days. The concave dial and bar control, giving ease of adjustment without cramping the hand, is far more sensible and attractive.



EISEMANN PARTS AND PANELS

Permit changing circuits and re-location of parts on panel—all units being interchangeable.

Make unnecessary the use of shielding—the metal panel itself accomplishing this purpose.

Eliminate mounting of tap-switches and soldering of primary leads.

Give the many advantages of concave dials—a natural position of the hand in tuning, added attractiveness in appearance and ease in packing for transportation.

Write for descriptive literature.

EISEMANN MAGNETO CORPORATION
William N. Shaw, *President*
BROOKLYN, N. Y.

DETROIT **CHICAGO**

EISEMANN

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—for panels!

Bakelite-Dilecto (xx grade) is the one material you can absolutely depend upon to be perfect for radio panels.

bakelite-dilecto!!

(A *Laminated Phenolic Condensation Product*)

It's handsome. It's tough. It's durable. Yet machines readily.

It resists heat, water, steam, fumes and mild acids. It cannot warp or swell.

Highest dielectric resistance. Used over 8 years in the U. S. Navy and Signal Corps. Have any electrical man get it cut and drilled to size.

THE CONTINENTAL FIBRE CO.
FACTORY: NEWARK, DELAWARE

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Seattle, 95 Connecticut St.
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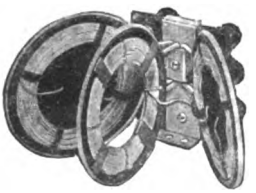
Tune into Results with this New and Better Device



MARCO TUNER

Type 300A

Body Capacity Practically Eliminated

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As a Single or Double Circuit Tuner

this instrument is most useful, particularly for tuning simple, efficient regenerative sets.

As a Radio-Frequency Transformer

it is the most generally satisfactory piece of apparatus on the market today, *providing in itself* an aerial tuning inductance and an intertube coupling impedance which is variable, compensating for changes in wave length or differences in inter-electrode tube capacities, allowing successful operation with any of the new *low amperage tubes.*

In the Flewelling Circuit

all the interesting phenomena of super-regeneration may be observed through the use of this device.

In Any Combination Requiring Small Inductances

this arrangement of coils will provide the necessary values for broadcasting reception, and will work well, with a pleasing lack of body capacity effect in adjustment.

MARTIN-COPELAND COMPANY
Providence, R. I.

Amrad Variometers

New Price $3.75

Most efficient variometer on the market. No dielectric losses, small mounting space required. New automatic machines used in manufacture brings their price within the reach of every Radio Fan. Immediate delivery on all mail orders.

Variometer, less dial	$3.75
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Jefferson Transformers, No. 41	$4.25
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New Loose-Leaf Catalog Now Ready

Contains complete description, circuit diagram and list of material for building the NEW GRIMES INVERSE DUPLEX RECEIVER.

Send 10c for your copy.
New sheets supplied free of charge every month.

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Sixth Floor, Consumers Building
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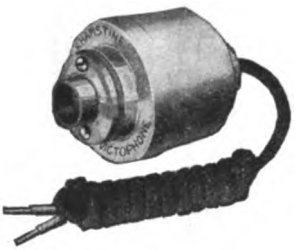
RHAMSTINE*

Victophone

A NEW LOUD-SPEAKER



Price

$7.50

Complete with Phone Cord

Remove the reproducer from your Victrola and put on the Rhamstine* *Victophone,* adjust the pole regulator until the tone and volume are just right—and see if it does not fully meet your needs for a perfect loud-speaker.

The *Victophone* is a correctly designed loud-speaking receiver—it requires no battery to operate it. It can be used with any type of horn but it is especially designed to be attached to the tone-arm of various phonographs.

It possesses these superior qualities:

1. **Adjustable poles.**
2. **A venturi opening in the cap correctly designed to increase volume.**
3. **Rubber gasket between the tone-arm flange and the cap to reduce metallic vibrations.**

The *Victophone* is nickel-plated and highly polished. It bears the name Rhamstine,* assuring you of satisfaction in your purchase.

Order yours today. Dealers write for discount.

Manufactured by

J. THOMAS RHAMSTINE*

2162 E. Larned Street **Detroit, Michigan**

Maker of Radio Products

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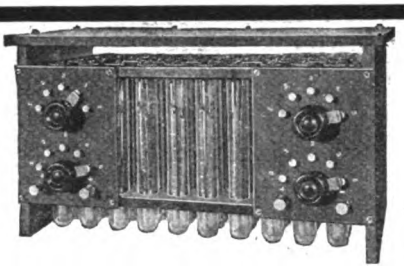

KICO Radio Storage "B" Batteries for EFFICIENT Receiving

1. KICO "B" batteries allow single cell variations by means of switches mounted on panels. (The first in the market with this feature.)
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4. One charge lasts from three to six months in the detector plate circuit.
5. Neat, efficient and compact.
6. Unlimited life.
7. Your money back if unsatisfied within a 90-day trial.

		(Plain)	(With Panels)
16 cell	22 volt	$6.50	.....
24 cell	32 volt	8.00	$12.00
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78 cell	100 volt	16.00	21.00
108 cell	145 volt	21.00	26.00

"A" and "B" Battery Literature gladly furnished

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Branston Lateral Wound Honeycomb Coils

Manufactured Under Deforest Patents

The finished product resulting from many years' experience in coil winding.

They are the most efficient and practical radio inductance ever designed. Sold unmounted or mounted with Branston Standard Mountings.

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Turns	Unmounted	Mounted
L25	$ .50	$1.40
L35	.50	1.40
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L100	.65	1.70
L150	.70	1.75
L200	.75	1.80
L250	.80	1.85
L300	.85	1.90
L400	.90	1.95
L500	1.00	2.20
L600	1.15	2.35
L750	1.35	2.60
L1000	1.60	2.85
L1250	2.00	3.30
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3 Coil Bakelite Adjustable Mounting $5.00
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Order through your dealer or write direct for complete catalog showing Branston "Standard" Radio Accessories.

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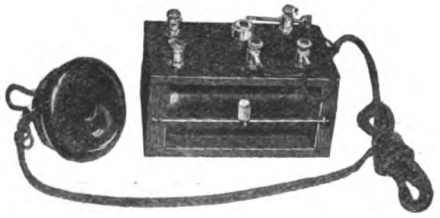
"VB" RADIO CRYSTAL SET

Very Simple and Efficient



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is told, complete with illustrations and diagrams, in the latest addition to the "Chi-Rad" Handbook-Catalog.

Our Handbook also includes:

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Send for it, today!

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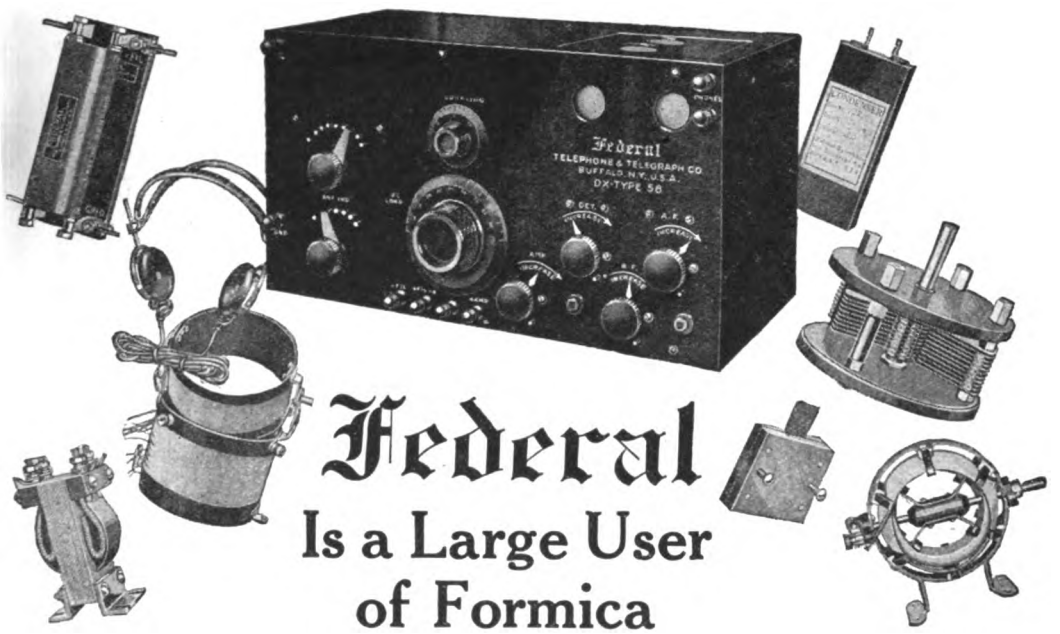

Federal Is a Large User of Formica

THE FEDERAL TELEPHONE AND TELEGRAPH COMPANY of Buffalo is a large factor in the radio industry and has an excellent reputation for the quality of its product.

It is a very extensive user of Formica insulation not only in the complete sets which it produces but in the radio parts, variometers, variocouplers, headsets of which it is a large manufacturer.

A list of the users of Formica reads like a directory of the leading independent radio manufacturers. So many of the best informed radio men in America cannot be mistaken in their opinion that Formica is most uniform, the best looking, and the most efficient radio insulation.

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FORMICA
Made from Anhydrous Redmanol Resins
SHEETS TUBES RODS

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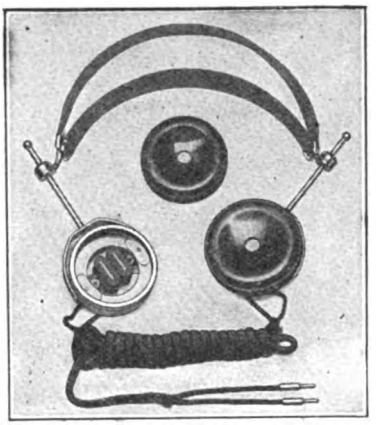
RADIO

HEADPHONES



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Add 20 cents for postage MONEY BACK GUARANTEE
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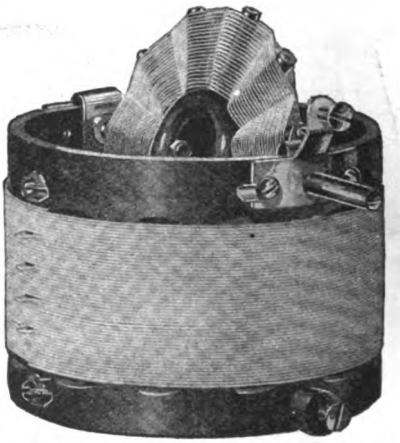

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WITH
SPIDER WEB ROTOR
PROVIDES
REMARKABLE SELECTIVITY IN TUNING
Designed for us by Alfred A. Crossley

Price $6.50

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THE HARTMAN ELECTRICAL MFG. CO.
MANSFIELD, OHIO

Listen in with a

Dodge TONE AMPLIFIER

A scientifically perfect instrument, with wood pulp sound chamber, designed by one of the foremost acoustical specialists. This Perfect Tone

RADIO LOUD SPEAKER

insures the most delicate reproduction of voice or music and positively eliminates distortion and metallic sound.

The Dodge Tone Amplifier is enclosed in a handsome mahogany cabinet, with front panel and sound chamber finished in black. Size of complete outfit: 12 in. high, 9¾ in. wide, 8¼ in. deep.

The Dodge Tone Amplifier is made especially for home use, with any set of three tubes or more. No batteries necessary. No adjustments. Complete, ready for immediate use. Merely hook up and listen. Price..... **$25.00**

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Announcement to our Numerous Friends!

Beginning May 1, 1923, the

MORTIMER RADIO CORPORATION

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ADVANCE METAL STAMPING CO.

both of New York City, will consolidate and be known in the future as

AMSCO PRODUCTS, INC.

The "Melco Supreme" Radio-Frequency Receiver will continue to be marketed under its own name and a complete line of high-grade parts will be available at good dealers under the Amsco brand.

Our new home in the

Fairbanks Building

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is up-to-date in every respect and will enable us to give even better service than has heretofore been possible.

A postcard will bring you our literature—describing both sets and parts.

Thank You!

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Red Seal SPARKER—steel clad

for every outing

Red Seal Radio Sparker

Specially designed for operating WD-11 Tubes. Radio Sparkers give nearly three times longer service than a single dry cell. Made in 2-cell, 6-cell and 8-cell sizes for operating one to four WD-11 Tubes.

For economical operation specify **Radio Sparkers.**

This summer let the Red Seal Sparker—steel clad—supply dependable power for your outing needs. A fat, full spark for your motor boat ignition—a quick, sure start for your car—lighting up your camp lantern—Red Seal is always on the job, long lived, efficient.

For tractors, stationary engines, and so forth, farmers also find Sparkers—steel clad—stand all kinds of hard knocks.

The Red Seal Sparker—steel clad—is made in three sizes: 4 cells, 6 volts; 5 cells, 7½ volts; 6 cells, 9 volts.

Be sure to ask for it by name—Red Seal Sparker—steel clad.

MANHATTAN ELECTRICAL SUPPLY CO., INC.

Makers of the famous Red Seal Dry Batteries, Sparkers and Manhattan Radio Products.

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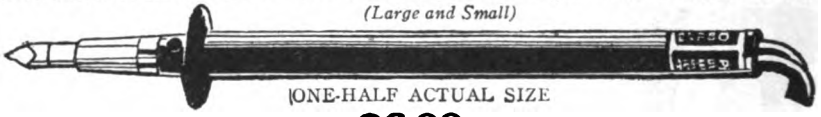
DELICATE SOLDERING in RADIO

Both the manufacturers' and amateurs' problem on all fine work is readily solved by the instrument constructed for this particular purpose.

THE POST SOLDERING IRON

Platinum Heating Unit—Interchangeable Tips—Universal Current

(Large and Small)



ONE-HALF ACTUAL SIZE

$6.00

Awarded Certificate of Excellency, N. Y. Evening Mail Radio Institute

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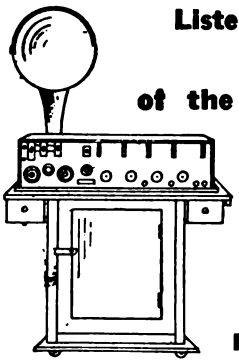

Listening across the continent—New York to California

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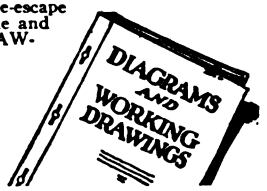
of the Famous MAWHINNEY RECEIVING APPARATUS

A series of 7 blue prints giving in full detail all the necessary information, specifications, and method of construction, and assembling of the MAWHINNEY RECEIVING Apparatus. This is the 5-tube receiving set that startled the radio world by picking up 5 stations on the Pacific Coast with only a fire-escape as an aerial. The Blue Prints tell you in a very simple and clear manner just how to construct a duplicate of MAWHINNEY'S trans-continental receiving set.

If your dealer cannot supply you—
Send $2.00 for complete set of prints.



A. S. MAWHINNEY

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RADIO BLUEPRINTS

Blue Print Design of Radio Receiver, guaranteed range 1,000, 3,000 miles, using dry cell.....10c
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Guaranteed 1000 Ohm Phone Receiver Postpaid $2.00
Guaranteed Bakelite Couplers, Green Silk Prepaid $3.00

We sell Guaranteed Apparatus.

Send 10c for Our Complete Catalog!

Agents Wanted—Liberal Commissions

Badger Radio Co., 493 E. Water St., Milwaukee, Wis.

FREE Radio Catalog

Our big stock of standard makes of radio sets, parts and supplies, fully illustrated. Play safe—buy standard equipment from a reliable house. We ship from stock.

Send $5.00 for Murdock Loud Speaker, including fibre horn, stand and adjustable phone unit. Requires no battery.

JULIUS ANDRAE & SONS CO.

In business since 1860

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DUCK Radio Pioneer Announces Startling Reductions

Leading Line Since 1909 At Prices to You Less Than Dealers' Cost

FREE Illustrated pamphlet comprising sixty-two Duck radio instruments and sets with reductions averaging 30% mailed on request. Send postal today. Any old-time radio amateur will tell you who we are and our reputation. Only a few years ago almost one-third of the radio instruments sold at retail, exclusive of sales in only a half dozen large cities, were sold by Duck.

A Few of the Many Duck Products at Sensational Prices:

Rheostat, 70c; Bakelite moulded positive contact Socket, 70c; Bakelite Moulded Dial, 55c; superselective moulded variometer, $4.65, worth $8.00; radio frequency potentiometer, $1.15; solid mahogany form variometer, $3.60; 43-plate panel-type variable condenser, pigtail connection, $3.15; detector panel, $5.25; receiving set, mahogany cabinet, detector and two stages of audio frequency, $59.50; radio frequency receiving set with one-step radio and detector, $29.75.

SEND 25c in coin or money order for our big 256-page combined radio catalog and text book. For radio information and hook-ups it is worth many times the retainer asked.

THE WILLIAM B. DUCK COMPANY, 227-229 Superior St., Toledo, Ohio

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Dependable Radio Sets and Service

Can always be had from local dealers who have been honored with the

M.R.C. FRANCHISE

For Three Reasons:

1. Franchise is granted only to merchants of standing and financial responsibility, with sufficient technical experience to render intelligent service.

2. "Michigan" Radio Sets are the finest examples of correct Regenerative radio engineering, expressed in superlatively good workmanship.

3. The Michigan Guarantee is as valid as a Bond. For back of it stands the strongest independent Radio manufacturing concern in the United States.

"SENIOR" SET

Michigan Regenerative Receiving Sets

are built under Armstrong License (U. S. Pat. 1,113,149 and letters patent No. 607,388). This means that they embody the latest development in Regeneration—the soul of radio.

Long Distance Wonder Workers

"JUNIOR" SET

The "Senior Set" includes both detector and amplification, and can be used with either headphones or loud speakers or both.

The "Junior Set", a detector unit only, is limited to headphone reception. It can however, be hooked up with the Michigan Amplifier unit for loudspeaker reception.

Send for the Michigan Circular, giving full information on both sets and parts, and telling of some of the long-distance triumphs of Michigan set owners.

MICHIGAN RADIO CORPORATION

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Specials for this month only

Single Circuit Jacks	$ .50
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Audio-Transformers	4.00
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45 Volt "B" Battery	3.25
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3" Dials	.45
Variometer	3.50
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10c will bring you our new and up-to-date catalogue illustrating and describing our entire line—containing diagrams and other interesting data of value to radio fans.

All merchandise guaranteed by both the Manufacturer and ourselves. Shipped immediately on receipt of purchase price and postage.

THE NEW RT-8

Radio Frequency Transformers are specially designed by the **Radio Service LABORATORIES** for maximum efficiency when used with any low current consumption tubes on the market.

For Audio Frequency, the new RT-A2 will give you 100% Tone Quality and High Amplification without distortion. For best results on both tone and distance, use Radio Frequency RT-8 (for all stages) in the black case, retail price $6.00, and Audio Frequency RT-A2 in brown case, retail price $6.50. For sale at all reliable electrical or **Radio** Stores. If your dealer cannot supply you, order direct. Order by type number, accept no substitute, and remember that all **Radio Service Laboratories'** Transformers are individually triple tested and unconditionally guaranteed.

Send ten cents for booklet on Radio Frequency with schematic diagrams—a most valuable and helpful publication for the radio amateur and expert.

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WE LIVE IN KANSAS

But we receive programs from Atlanta, Minneapolis, Davenport, Fort Worth, Dallas, Kansas City, St. Louis, Denver, San Antonio on crystal without batteries. Your crystal set requires only easy, inexpensive changes. Send stamp for further information, or $1 for copyrighted drawing and instructions. Everything clearly explained. Satisfaction guaranteed. LEON LAMBERT, 505 South Volutsia, Wichita, Kan.

Solder it with a

Here It Is

The handiest tool ever devised for soldering connections on Radio sets, repairing wiring connections in your house and on your car, mending kitchen utensils.

Fine for close, careful work. Produces a 1400° needle-point flame instantly. Used by electricians and mechanics everywhere.

60-in. coil self fluxing (acid or rosin core) solder ..25c
Lenk Super (blows itself) torch..... 75c
Lenk Jumbo (blows itself) torch..... $1.00
Marvel Soldering Kit—one Lenk Jumbo Blow Torch and two coils—one acid and one rosin core—self-fluxing solder, in neat leatherette case $2.00

LENK MFG. CO.
40 Portland St. Boston, Mass.

DELFELCO RADIO B BATTERIES
ARE GUARANTEED

Small 22½V	$2.00
Small 45V	4.00
Large 22½V	3.00
Large 45V	5.50

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DELFELCO BATTERY CORP.
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GIVE YOUR EARS A TREAT!—USE

"RED-HEADS"

3000 Ohms

Now $6.50

With Military Head-Band and Cord

At your dealers or direct on receipt of price.

A Triumph in Radio Receiver Design

The Newman-Stern Co.

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The New Pathé

Reproducing Revolutionized

Based on our experience of over a quarter of a century, as manufacturers of musical instruments—and as highly specialized acoustical engineers, we have produced the PATHÉ LOUD SPEAKER which will mark a new era in loud speakers.

It is something decidedly different. It utilizes an entirely *new* principle. And as a result it converts tone with an exactness never before accomplished by a "loud speaker."

No horn of any type is used. No small metallic diaphragm is hidden away at the end of a horn or in the depths of a cabinet. What you suppose on first inspection to be a stubby sort of a horn, is a parchment diaphragm of abnormal size.

WITHOUT DISTORTION the sounds are given directly from this diaphragm, propagating the waves in free air rather than by reflection from the sides of a horn device.

The Pathé Loud Speaker possesses an unrivaled combination of distinct advantages. Briefly:—

It distributes the sound in all directions—and *does not* confine or "shoot" it toward one point as a horn does.

It does not require an extra battery. Simply attach it in place of the ear phones.

On the home sets of two steps of amplification it will flood the room with clear tone. On larger sets, it will produce any volume of sound required—WITHOUT DISTORTION.

It is compact, size 14¼" high x 7" wide, and it will grace any living room.

The cost is much lower than you expect—

$24 for nickel finish
$22 for Japan Green finish

If your dealer has not received his Pathé Loud Speakers, we will make you shipment direct from the factory. Simply enclose money order or check and say, send me The Pathé Loud Speaker.

Pathé Phonograph & Radio Corp.
Dept. 4355, 20 Grand Ave., Brooklyn, N. Y.

Send the Coupon

Pathé Phonograph & Radio Corp.,
Dept. 4355, 20 Grand Ave., Brooklyn.

Please send me the Pathé Loud Speaker.

I am enclosing $..... It is distinctly understood that I may return the Loud Speaker if it is not entirely satisfactory—and my money will be cheerfully refunded.

Name .....

Address .....

Town .....

Pathé the World Over

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1200 MILES
with a Crystal Set Using

A Needles, California, radio fan writes:

"Using M. P. M. Crystal, I picked up Los Angeles, San Francisco, Salt Lake, Denver and St. Louis. It is far superior to any crystal I have ever used."

Before discarding your Crystal Set for an expensive Tube outfit, give M. P. M. Crystal a trial!

¶ ***Beware of imitations!*** The genuine Million Point Mineral is sold only in separate crystals packed by our company in boxes bearing the trade-mark "M. P. M."

Send 25c and name of your Radio Dealer for a sample M. P. M. Crystal—concert-tested and guaranteed. 35c for mounted Crystal.

M. P. M. SALES COMPANY
Department PR
247 So. Central Ave. Los Angeles, Cal.

PRICES *SMASHED*

Each sale has created new friends and customers, with the result that we now announce drastic reductions in our quality lines. All goods prepaid. Send card for complete list. You'll be surprised. You'll tell your friends. A sample saving follows—

Complete Regenerative Vacuum Tube Set
(Knocked down. Approx. range 1000 miles.)

	Our price	Others
Panel 7" x 12"—Bakelite—drilled	$1.75	$2.50
Cabinet of 3 ply wood to fit above panel	1.50	2.50
Two 3" dials @ 35c each	.70	1.40
16 switch points with nut @ 1c each	.16	.48
4 switch stops with nut @ 1c each	.04	.12
8 nickel plated binding posts @ 3c each	.24	.48
2 switch levers @ 25c each	.50	.90
1 filament rheostat. Highest grade	.65	1.10
1 vario-coupler with 7 multiple, 7 single taps	2.25	4.00
1 23 plate variable condenser. Built right	1.95	3.50
1 tube socket—High grade	.45	.85
1 grid condenser and leak	.20	.35
1 phone condenser	.15	.30
1 support for tube socket	.15	.25
10 feet of spaghetti tubing @ 5c per foot	.50	.84
15 feet copper connecting wire	.15	.30
Blueprints showing details to assemble outfit	.10	.25
	$11.44	$20.12

Other articles taken at random from our list are:

Detector tubes—Cunningham—New. NOT rebuilt	$4.25	$5.00
Amplifying tubes—Cunningham—New. NOT rebuilt	5.50	6.50
Transformer—Audio frequency. United	2.95	4.50
Variometer—Hardwood Stators 4¾" square. Assembled Workrite type	2.45	4.00
Frost Fones .....2000 ohms	3.95	5.00
Dictograph .....3000 ohms	6.50	8.00
Stromberg Carlson..3000 ohms	5.95	7.50
Murdock .....3000 ohms	4.75	5.50
Holtzer Cabot ....2200 ohms	6.25	8.00
Manhattan .....2000 ohms	4.95	6.00
Manhattan .....3000 ohms	5.50	7.00
Two stage amplifier—Knocked down. Cabinet and drilled panel	12.95	23.50
Blueprints giving detail of two stage amplifier	.10	.25

Send for full list today or order from above. Goods sold subject to return for rebate or exchange. YOU SIMPLY MUST BE PLEASED.

RADIO PARTS MANUFACTURING CO.
Dept. "P" 2150 Montclair Detroit, Mich.

In Any or All Stages
of audio frequency amplification
The AMERTRAN

Price $7
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can and should be used. It is made in only one type and one ratio. Its flat-top amplification curve precludes the possibility of distortion on the part of the transformer when used in any or all stages. It will give the same clear-toned distortionless amplification with all tubes which are approximately alike in A. C. Impedance and Amplification Factor, such as

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UV-201 UV-201-A
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Its amplification in one stage is 38.6; two stages 1490.

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April, 1923

Filkostat Proven Best Filament Control

Comparison of Fine Adjustment Control Range of Filkostat With Rheostats and Other Filament Controls Clearly Indicates Filkostat Superiority, as It Permits Perfect and Gradual Current Increase With Infinite Adjustments.

IN the Filkostat, a new filament control just perfected by S. R. Hipple, well known as an inventor of apparatus for the control of electric currents, there is at last presented an instrument which is distinctly designed to utilize the great tuning possibilities of the vacuum tube itself. Radio set builders, amateurs and manufacturers have been looking forward to the advent of just such a device. They have realized that all rheostats and other so-called filament regulators, are merely adaptations of pre-radio day devices, not capable of adjusting the infinitesimal graduations of filament HEAT which adjustments are essential to perfect tuning.

PERFECT TUBE CONTROL

The Filkostat permits perfect regulation of filament heat. Since the heat emitted varies as the square of the current, fine current regulation becomes extremely necessary to accomplish. This governs the flow of electrons. Proper control of the electronic flow in the tube permits the very finest tuning conceivable. The fine adjustment of the Filkostat starts slightly before the tube begins to function. With other filament controls, what minute adjustment there is, starts when the filament is almost at maximum heat. Between 1800 degrees—dull red glow—and 2050 degrees—white heat—the Filkostat control is so fine that increases of temperature of *fractions of a degree*, with corresponding variations of electronic flow from the filament to the plate, are obtainable.

LONGER TUBE LIFE; NO NOISES

The initial inrush of current prevents the crystalization of the filament which so many experts claim occurs when the current is fed too slowly at first as is done in other forms of filament controls. This means considerable increase in tube life. Furthermore the extreme degree of fineness in increase and decrease of electronic flow by infinitesimal variations, makes the Filkostat control ideal.

The perfection of design including ample internal contact is the cause of this new instrument being non-michrophonic, absolutely silent, and free from all noises.

IDEAL FOR WDII'S AND DX WORK

The lower curve on the graph above is eloquent testimony as to the Filkostat's adaptability to any dry cell tube. These tubes using only a fraction of an ampere demand an instrument that is so finely adjusted that this fractional current can be perfectly regulated. This the Filkostat accomplishes.

OTHER FILKOSTAT FEATURES

The Filkostat has a *definite off*. It is so designed that the filament extinguishes abruptly indicating that the A battery supply is completely disconnected.

At *Full On* the Filkostat resistance is practically zero.

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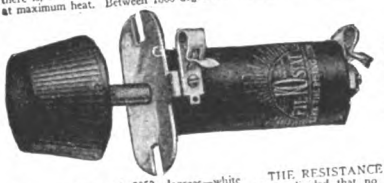

The Filkostat is to all purposes "fool proof." It is compact in form, takes very little space on the panel and so mountable that it can replace any other control without redrilling.

THE RESISTANCE ELEMENT is so finely divided that no further division is possible. There are no disks to break or chip.

The RESISTANCE remains CONSTANT at any position eliminating current variations once set. Such variations are not apparent to the person tuning excepting in "fading out" of stations and noises. But in the laboratory, where such a test as that shown on the above graph can be made by anyone, this feature and all the other points of superiority of the Filkostat are immediately apparent.

The filament kontrol of infinite adjustment

FIL-KO-STAT

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$2.00

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adjustment and not just an old method adapted to it.

NOT a Rheostat
—but a REAL *Filament Control.*

Infinitesimal Control—of filament heat
and therefore of *electronic flow.*

Very Finest Tuning for DX
is realized with Fil-Ko-Stat.

Controls Fractional Currents
—making it ideal for use with any dry cell tube.

Fine Adjustment Starts
—where tube commences to function increasing the AREA OF FINE ADJUSTMENT CONTROL.

Definite Off—
an important feature indicating complete 'A' Battery disconnection.

Resistance Practically Zero
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Fahnestock Clips
and solder contacts on connection posts.

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Cabinet of 3 ply wood to fit above panel	1.50	2.50
Two 3" dials @ 35c each	.70	1.40
16 switch points with nut @ 1c each	.16	.48
4 switch stops with nut @ 1c each	.04	.12
8 nickel plated binding posts @ 3c each	.24	.48
2 switch levers @ 25c each	.50	.90
1 filament rheostat. Highest grade	.65	1.10
1 vario-coupler with 7 multiple, 7 single taps	2.25	4.00
1 23 plate variable condenser. Built right	1.95	3.50
1 tube socket—High grade	.45	.85
1 grid condenser and leak	.20	.35
1 phone condenser	.15	.30
1 support for tube socket	.15	.25
10 feet of spaghetti tubing @ 5c per foot	.50	.84
15 feet copper connecting wire	.15	.30
Blueprints showing details to assemble outfit	.10	.25
	$11.44	$20.12

Other articles taken at random from our list are:

Detector tubes—Cunningham—New. NOT rebuilt	$4.25	$5.00
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Variometer—Hardwood Stators 4¾" square. Assembled Workrite type	2.45	4.00
Frost Fones .....2000 ohms	3.95	5.00
Dictograph .....3000 ohms	6.50	8.00
Stromberg Carlson..3000 ohms	5.95	7.50
Murdock .....3000 ohms	4.75	5.50
Holtzer Cabot ....2200 ohms	6.25	8.00
Manhattan .....2000 ohms	4.95	6.00
Manhattan .....3000 ohms	5.50	7.00
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Blueprints giving detail of two stage amplifier	.10	.25

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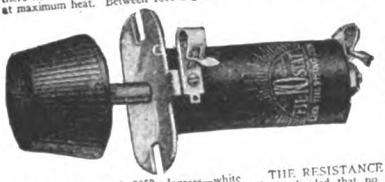

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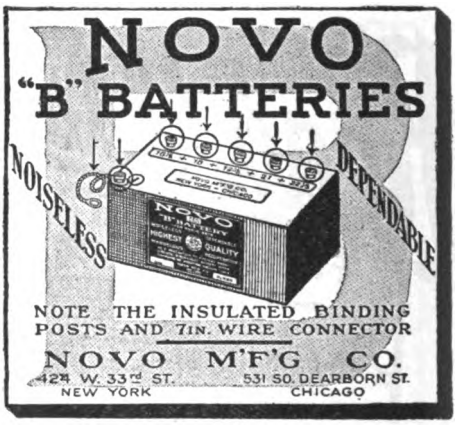

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Since the issue of May, 1922, the magazine has made a host of admiring friends. Our little family of subscribers has grown to number approximately ten thousand. Our newsstand friends total close to a hundred thousand.

In almost every city and village where radio sets are in operation POPULAR RADIO is giving its readers practical hints and suggestions on how to build their own sets, how to widen their range, how to make improved hook-ups—is bringing to the radio novice and amateur the most authoritative information that can be had.

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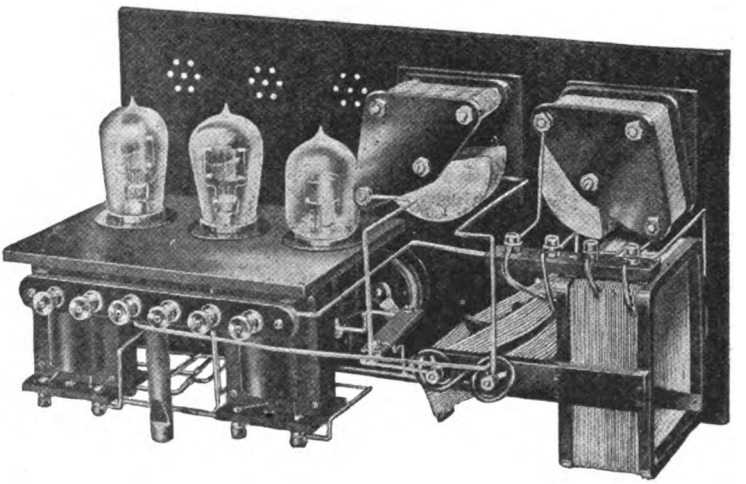

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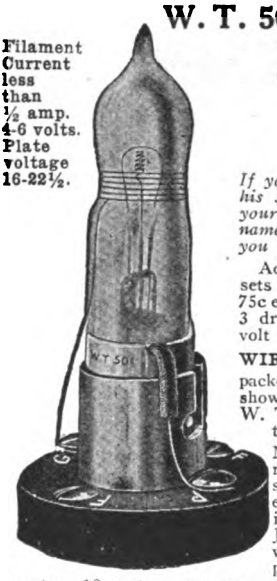

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COMPARE THESE PRICES

RADIO PRICES:	
6 Volt. 40 Amps.	$10.00
6 Volt. 60 Amps.	12.50
6 Volt. 80 Amps.	14.50
6 Volt. 100 Amps.	16.00

No other manufacturer offers such a high quality battery at such a low price. Save 50 per cent on your next battery and get better and longer service—buy a **World Storage Radio Battery.** Write today.

World Battery Co., 1219 S. Wabash Ave., Dept. 3, Chicago

ACME

for amplification

RADIO TUBES REPAIRED

Six volt Tubes repaired equal to new

REFILLED TUBES IN STOCK

Write for details of our new L. D. Radio Frequency Transformer $2.75, Agents wanted

RADIO TUBE LABORATORIES, Inc.

Tube and Transformer Specialists

776 Broad St. Newark, N. J., U. S. A.

SPECIAL OFFER

Two new yearly subscriptions to POPULAR RADIO for only.... $3.00

Rope this Special Offer. Any radio enthusiast can do it. You and a friend of yours may have POPULAR RADIO for a whole year, provided you are both NEW subscribers. You only have to throw a check for $3.00 around the double coupon and MAIL IT TO-DAY.

(Coupon good until May 20th, 1923)

POPULAR RADIO, Dept. 52,
9 East 40th Street, New York City
Please send POPULAR RADIO for one year to:

NAME.....

ADDRESS.....

CITY..... STATE.....

And also to this other new subscriber. Here's my cash remittance—(or a check or money order for $3).

NAME.....

ADDRESS.....

CITY..... STATE.....

(No extra for Canada. Foreign countries 25 cents extra per subscription.)

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TRADE MARK

Wave Trap

PATENT APPLIED FOR

The Missing Link in RADIO

Stops Interference!

The "WAVE TRAP" will eliminate interfering broadcasting stations and enable you to listen to your favorite station.

It will work on any set, greatly increase its selectivity and clearness, and eliminate code and spark stations.

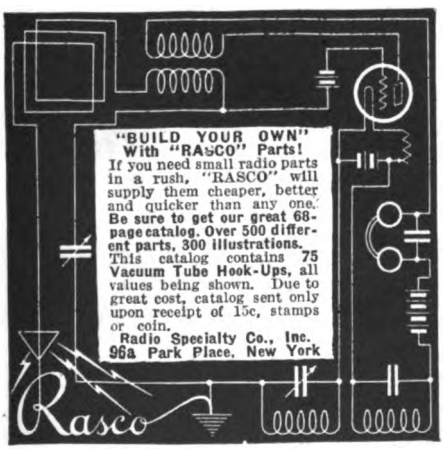
It is mounted on a Formica panel in a handsome mahogany finished cabinet 6x5x6. It is a high grade instrument throughout and a valuable addition to the operation and appearance of any set. It comes to you complete and there are no extras to buy. It is installed in a minute by changing only one outside connection.

Use the "WAVE TRAP" for real results.

8.50 CHARGES PREPAID

Ferbend Electric Co.
21 E. SOUTH WATER ST.
CHICAGO

Circular on request.



SEE PAGE 60
for Special Offer

6 Volt 120 A.H. RADIO BATTERY IN LEAK PROOF RUBBER CASE $25.00

The Radio Battery You Have Been Waiting For

A high grade, long-life, 11 plate radio battery in absolutely leakproof rubber composition case with victrola style cover. Protects your rugs and floors from destructive acid. Makes your "A" battery as handsome as your receiving set.

Positive 18 Months Guarantee

Guaranteed for full 18 months of service. Non-warping cedar separators, highest quality plates of generous thickness. 6 Volt—120 Ampere hour type. Sealed terminals save electrolyte and protect connections. Positively will not short circuit. Fitted with convenient handle and anti-drip tray. Price, complete, fully charged, $25.00. Neat switch in cover supplied for $1.50 extra.

"As good as its name"

NOTE THESE LOW "A" BATTERY PRICES

Noble Radio "A" Batteries in Everlastic Rubber Cases

Type	Rating	Plates	Price
Junior	80 Amp.	7	$14.80
Senior	100 Amp.	9	17.90
Standard	120 Amp.	11	19.70
Superior	140 Amp.	13	21.70

Noble "A" Batteries in Maple Cases, Black or Mahog. Finish

Type	Rating	Plates	Price
Junior	80 Amp.	7	$12.75
Senior	100 Amp.	9	15.90
Standard	120 Amp.	11	17.75
Superior	140 Amp.	13	19.45

Covers for above batt. $1 extra. You may be able to buy batteries as good as ours, but none that are better.

NOBLE

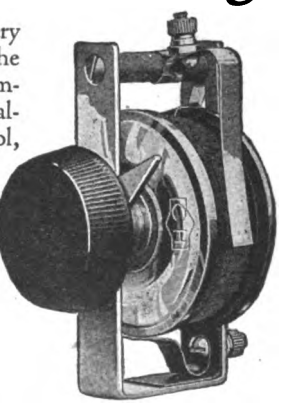
Address Dept. P

Order today, sending check or P. O. money order, or we ship express C. O. D. same day order is received.

NOBLE BATTERIES
1454 MONADNOCK BLOCK - CHICAGO

Increase Your Range

This new "A" Battery Potentiometer by the engineers of Cutler-Hammer, world-known specialists in rheostatic control, will bring new stations to your receiving set, and give you increased signal strength for better reception.



It is correctly designed for maximum service—with a resistance unit that cannot be displaced under constant usage. Demand the C-H trademark—*it is your guarantee of satisfaction.*

Resistance 300 ohms. Panel Mounting. Pointer Indicating. Adjustable Contact Fingers. Genuine Thermoplax Knob Convenient Binding Posts for easy wiring. Finished in dull satin nickel.

Type 11602 ..... $1.50

THE CUTLER-HAMMER MFG. CO.

Member Radio Section, Associated Manufacturers of Electrical Supplies

MILWAUKEE - WISCONSIN

Over a Quarter Million C-H Radio Rheostats Now in Use

C-H RADIO "A" BATTERY POTENTIOMETER

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Critical tuning with the Dubilier Ducon

THE Dubilier Ducon is the only device of its kind passed by the Laboratories of the National Board of Fire Underwriters. Several hundred thousand radio "listeners in" in America and Europe use it to do away with the cumbrous antenna and its lightning arrestors and switches.

With the Dubilier Ducon in a lamp socket, the tuning is so sharp that the slightest movement of the knobs is sufficient to suppress one of two stations on nearby wave lengths.

Hence the Dubilier Ducon not only makes it easy to enjoy radio by doing away with the antenna, but gives to the simplest set a selectivity in tuning attainable only in the most expensive and elaborately equipped apparatus.

DUBILIER CONDENSER AND RADIO CORP.
48-50 West Fourth Street, New York

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Washington, D. C., Munsey Bldg.
Chicago, Ill., 33 So. Clinton St.
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Distributed in Canada by

Canadian General Electric Company, Ltd., Toronto
England: Dubilier Condenser Co., Ltd., London
Germany: The Telefunken Co., Berlin
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Retail price $1.50. At all good dealers. The Dubilier Ducon is used throughout the world

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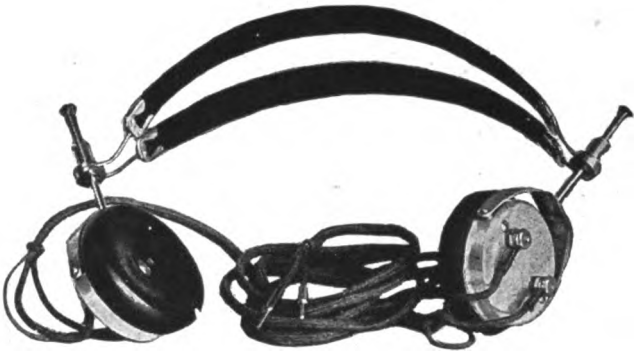
Teleradio

(TRADE-MARK)



SUPER SENSITIVE PHONES

USED IN EVERY STATE IN THE UNION

are the result of years of experience in the construction of delicate electrical apparatus.

They are designed and built on sound engineering principles. They are famous for their super sensitiveness, superior quality of tone, volume, and clearness—accurately reproducing either vocal or musical sounds with wonderful tonal qualities. *Equally satisfactory for local or long distance work.*

Growing popularity — INCREASING SALES prove it is the PERFORMANCE and SATISFACTION of TELERADIO *correctly balanced* Phones that really count.

TRY THEM AND BE CONVINCED

Type C, 2000 ohms, **$6.50**; Type B, 2200 ohms, **$7.50**; Type A, 3000 ohms, **$9.00.**

TELERADIO FILAMENT RHEOSTAT

Can be mounted on panel or table

Will carry 1½ amps without overheating and is wound to 6 ohms resistance

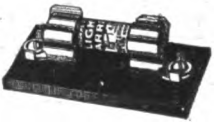
Price, **$1.00**

TELERADIO LIGHTNING ARRESTER

Electrical No. 5837

Approved by the National Board of Fire Underwriters

Price, **$1.00**



TELERADIO FILAMENT PROTECTOR

For detector and amplifying tubes

Complete, **60c**

Extra fuses, **10c** each

OTHER TELERADIO "HIGH QUALITY" PRODUCTS

Variable Condensers, 3-11-23 and 43 plates, **$1.50, $2.50, $3.00** and **$4.00**, respectively. Tube Sockets, **60c**; Fixed Phone and Grid Condensers, **35c** each; Grid Leak Condensers, **50c** each.

If your dealer has not stocked TELERADIO PRODUCTS order direct and mention dealer's name. Jobbers: Write for our discounts. Dealers: Ask us about our "Dealer's Stock Order" proposition

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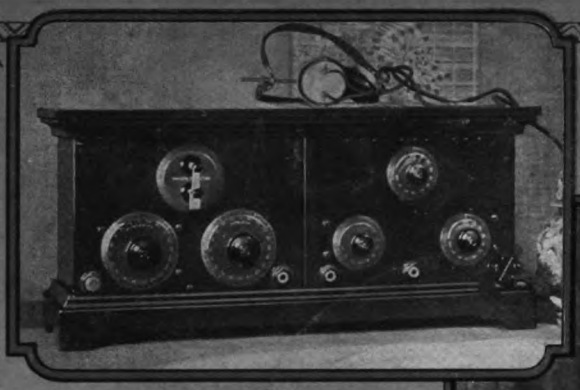

Radiola V

Mahogany finished case, of rugged build. A three tube Radiola—detector and two steps of amplification.

Radiola RC

Three tube set—detector and two step amplifier. Solid mahogany, attractively finished.

A New Improvement Lowers the Cost!

Dry cells replace storage batteries. A new vacuum tube has made it possible. Radiola V and Radiola RC have been topping them all in popularity for dependability and long range—receiving over thrilling distances—up to 1,500 miles and more. Now both are converted to dry battery operation.

No more need for expensive storage battery and charger. A big saving! And a saving made greater by the new offer—a combination offer of receiver and accessories—complete at a price remarkably low.

"There's a **Radiola** *for every purse"*

at the nearest Radio or Electrical Store

This symbol of quality is your protection

RCA

Radiola V *or* Radiola RC Complete $142.50

The New Way: Complete for dry battery operation, including three WD-12 Radiotron vacuum tubes; head telephones; "A" Battery consisting of three dry cells; "B" battery consisting of three 22½ volt units. $142.50.

The Old Way: The price of Radiola V or Radiola RC when equipped for storage battery operation, formerly came to $207.50.

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